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THE INDUSTRIAL SELF-INSTRUCTOR

THE

INDUSTRIAL SELF-INSTRUCTOR

AND TECHNICAL JOURNAL.

CONTAINING INSTRUCTIONS IN

The Leading Branches of Technical Science and Industrial Arts and Processes.

COMPRISING

BUILDING AND MECHANICAL DESIGN AND CONSTRUCTION—
MATERIALS USED IN THE ARTS AND SCIENCES—
MANUFACTURES—CHEMICAL INDUSTRY—
ART MANUFACTURES—RURAL WORK—
TECHNICAL DRAWING AND DESIGN;

WITH PRACTICAL USEFUL AND TECHNICAL NOTES, FACTS, AND FIGURES, FOR READY REFERENCE.

BY NUMEROUS PRACTICAL WRITERS AND TECHNICAL EXPERTS

Illustrated

WITH

WORKING DRAWINGS, DESIGNS, AND DIAGRAMS.

VOLUME I.

WARD, LOCK, AND CO., LIMITED.
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WARD AND LOCK'S
INDUSTRIAL SELF-INSTRUCTOR,
A Book for Home Study and Reference.

GENERAL ANNOUNCEMENT.

In introducing a re-issue of this important work under the above title, the conductors deem it right in the first place to glance here, as fully as space will permit, at the leading features of its various departments. This, they venture to believe, will show clearly how well deserved the claim of the work is, to be a guide to that class of information calculated to be practically useful to the large and influential body made up of our various industrial workers; and to possess for them a direct pecuniary value in enabling them to raise the worth of their services through the greater skill and accuracy which arises from a more perfect knowledge of the details of their work, and of the principles upon which that work is based. To be worthy of this place in practical literature, the work, as a whole, was based on certain leading principles adopted after long and anxious consideration. What those principles are, the value of which the first issue of the work abundantly proved, will be found detailed in the second paper in this part—this being the commencement of a special paper under the title of "Technical Education in relation to the Present Condition of our Industrial Work." In the short space at our command here, it is not possible to give a full *vidimus* or synopsis of the various subjects treated of, which would have any pretensions to be considered complete. At the best we can but glance at the most important of the papers which go to make up the pages of the work the re-issue of which the present part begins. Considering the evidences which everywhere surround us, the innumerable buildings filled with machines of every kind, the high reputation which we have long enjoyed, and still possess, as makers of the wide variety of objects used in the arts and sciences, and necessary to man in one or other of his many works and wants, it is scarcely necessary to say that a very important part of THE INDUSTRIAL INSTRUCTOR is taken up with papers on what, for lack of a better name, more descriptive, yet as concise and brief, are called the "Constructive Arts." Of these—as shelter for himself and his work is a prime necessity of man—the arts of "Masonry" and "Bricklaying" are treated in a thoroughly practical, yet suggestive manner. Naturally following upon these important subjects, come those in their way not less so—namely "Carpentry" and "Joinery," and the branch of work cognate to the latter known as "Cabinet Making." Closely connected with the work of the joiner and the cabinet maker are the departments of "Ornamental Wood Work" and of "Mouldings," each of which receives a careful treatment. And, as a natural adjunct to the papers above named, we have an important one taking up the designing of domestic houses, discussed under the title of "The Domestic House Planner," while many of the health-securing details are given under the title of "The Sanitary Architect." In the varied work of our manufactures, machines and mechanical appliances assume a highly important part. Many of the points connected with the design and the making of these are discussed in a series of most suggestive papers under the title of "The General Machinist"; while the same office is done for our principal prime mover or motor, and this under the title of "The Steam Engine User." In connection with materials nothing is more remarkable than the revolution which has taken place in the arts of iron and steel making, in which are displayed the highest developments of science, and the most strikingly ingenious and successful mechanical contrivances, combinations, and appliances. Hence particular attention has been given to the two subjects of which the titles are "The Iron Maker" and "The Steel Maker." But, as man requires the shelter of his house, so equally he demands clothing for the body; and of all the textile (*i.e.* woven) fabrics, cotton is the most largely used. The details of this manufacture, interesting in all its branches, will be found explained in the series of papers entitled "The Factory Worker." And closely connected with the making of calico is its ornamentation in "colour" and "design." The details of these are found in the papers entitled "The Calico Printer" and "The Colour Manufacturer"; while "The Alkali Maker" considers the points connected with the making of those substances which are the basis of a wide variety of manufactures. Then, as shelter and clothing are provided for, comes the production of food, with its imperious demands. Two of its most important departments—the crops and cattle—will be found in two papers, the one entitled "The Farmer," the other "The Grazier"; while cognate and highly important subjects are discussed in two further papers, "The Land Drainer" and "The Road Maker." Another department closely allied to farming work is that of the production of vegetables and fruit, the leading points of which are given in "The Market Gardener" and "The Cottage and Villa Gardener"; while several of the points connected with the ornamental laying out of the garden and grounds are illustrated in "The Garden Architect." But, as nearly all of the departments of industrial work we have named require the knowledge of certain principles of science, as well as a capability to design the different structures, machines, and appliances, information of this character is given in full detail in the papers entitled "The Student's Introduction to Mechanics," "The Young Architect and Engineer," "The Geometrical Draughtsman," "The Building and Machine Draughtsman," and "The Ornamental Draughtsman"; while several points of importance in relation to design will be found in the paper entitled "Form and Colour as applied to Industrial Decoration." In addition to these, the leading papers, there are a number of minor subjects, which, although comparatively brief, nevertheless still contain a large amount of practical information, such as the papers on "Belt and Pulley Driving Gear," "Friction," "Bessemer Steel Working," "Ensilage," "Steam Engine Boilers," "Water in the Industrial Arts," "Fuel and its Combustion," "Lubrication of Machines," and "Cements," together with a number of tables and memoranda containing a wide variety of practical information on nearly every branch of the "mechanical" or "constructive arts," and on "chemistry" applied to the arts, of great utility in industrial work.

Finally, the last feature of THE INDUSTRIAL SELF-INSTRUCTOR to which its conductors deem it necessary here to direct attention is the *Cyclopædic Technical Dictionary of the Leading Technical and Trade Terms in Architectural Design and Building Construction.* The value of this Dictionary was fully acknowledged during its publication, and it has proved itself a most attractive feature of our work. It gives in brief paragraphs a large amount of practical information, together with the derivations of the terms, with the valuable addition of synonyms in the French and German languages, the pronunciation of which—always a difficulty to those who have not a knowledge of these tongues—is made easy by a very simple and readily comprehended method of using English syllables.

Having thus given the reader a fairly complete statement of what subjects "THE INDUSTRIAL INSTRUCTOR" takes up and discusses, with a fulness of *illustration* rarely attempted in technical literature, the conductors deem it necessary, in the interests of those readers who are closely concerned with the practice of one or other of the many branches of what may be called by the general name of industrial work, to glance here briefly, by way of practical introduction, at the leading points of the great question which is now engrossing the public attention. This question is, how best to impart a specially practical education to those actually engaged in, or who are looking forward to being connected as workers with, the great branches of that industrial work which has placed our country in the highest rank of manufactures and trades, and given her that wealth and influence which has made her the first of prosperous peoples. This increased and increasing attention to the question as here broadly stated has arisen from the important fact that we, who at one time, and that not so very remote, possessed the monopoly of the world's manufacturing trade, and were practically the sole producers of the world's goods, are now face to face with a fierce competition carried on by the very people who, at one time, received virtually the whole of their supplies from us.

The causes which have brought this state of matters into existence—a condition of affairs simply of the gravest importance to us as a people—need not be here detailed. The reader will find them fully discussed, together with practical points which flow out of them, in the paper on "Technical Education in relation to the Present Condition of our Industrial Work," the first part of which will be found as the succeeding paper to this in the present number. Inviting the reader to carefully study the various points of this paper, as bearing in reality in the closest manner on his welfare as a worker, in whatever branch of industry he may be engaged, we proceed to glance at the leading features of the great question which we have named. For, however much men may differ as to the best way of meeting the difficulties of the present position, all are agreed that if anything can be done to enable us to regain our supremacy as manufacturers of every style of what are called by the comprehensive name of "goods," something ought to be done energetically, and done, moreover, at once; inasmuch as a continuance of remunerative employment for the vast body of our working population is a matter of the highest importance, than which, indeed, none can be higher nationally.

Amongst the methods proposed to bring about this most desirable end—and many claim it to be the only method—is that of imparting to our great body of workers, and to the youths who will one day belong to it, a knowledge of the principles upon which the practice of their work is based, so as to make them more skilful because working more intelligently, and thus to enable them to hold their own—indeed, to excel their fellow workmen in foreign countries, who are their determined and dangerous competitors, and who are said to be much better educated—technically—than they are, and are therefore much better able to compete with them.

To the peculiar style of education above named the name of technical has been given; and to the solution of the great question How best can it be imparted? the nation is now called upon to give its best attention, and as a necessity to devote much of its wealth. For to carry any scheme so effectively out as to be really worth the money it will cost, it must be universally adopted, so as to take in all districts of the kingdom. And this large expenditure means delay. For even if the legislature had decided to make a systematic effort to carry out technical education as a national work, much time would pass away before the system could be made generally available. What has been done as yet has been done by private munificence or corporate liberality; but, much as it appears, it is in reality little or nothing compared to what must yet be done. The conclusion, then, is inevitable, that it will be years before a national system of technical education is established; while during this interval the evil continues—nay, will almost certainly be more and more accentuated as time goes on; the competition getting more widely extended, more fiercely and forcibly developed.

And in this connection, a point of essential importance too long and too frequently overlooked is this: that the *national system*, when first established, will only be so in the towns, and of those only the largest, and it will be long before the provincial villages and rural districts are even touched. But it will be a huge mistake, and a grave one, if these are neglected, as a large number of our best engineers, mechanics, etc., have been "lads from the country."

But yet another point in this connection must be considered, and this is the direct relation of the working man to the public means which may be placed at his disposal for the acquirement of technical knowledge. Be it understood that we are not now considering the case of primary or school technical education for young people; we are referring now to those who are in their apprenticeship, or have just started as journeymen, with life and all its responsibilities before them, and who are impressed with a strong necessity to get on in their calling. It would be a libel on our working lads and men to say that the majority of them are not of this class. But if a census were taken of all those attending technical colleges, schools, and institutes, it would be matter of great surprise to many how small would be the percentage of the attendants belonging to the class of actual apprentices and journeymen who had only their physical health and strength, and their skill and ability in their respective callings, to depend upon for their living. But the technical education we all talk so much about is intended, if not wholly, certainly chiefly, for the *actual workers* of the community by whom the vast routine of our trades and manufactures is daily carried out. And the fact we have named, that so few of them, comparatively, avail themselves of the technical schools which are within their reach, is not so derogatory to them as many will be at first sight apt to decide. It can be accounted for by natural causes. What those are will be found fully detailed in the paper already alluded to on "Technical Education," following this paper in the present number.

The practical result of all that has been here advanced—and, did space permit, much more could be given—and also in the paragraphs of the paper on "Technical Education" we have referred to, is this. That for a long time to come it must be carried on, if carried on at all, by the working lads and men themselves anxious to get on in life, and secure, by what they can do *individually*, the maintenance of our natural supremacy as the best "workers" of the world. And, further, that this *self-education* can only, and this from the necessities of the case, in nine districts out of ten throughout the kingdom be carried out at *home*. Taking the actual facts of the present position, this is the inevitable conclusion to which practical men who *know* all the circumstances of the position have come. And it was with the wish to minister to the wants of the working classes mainly, and to place before them means by which they could in the privacy of their homes acquire a knowledge of those principles upon which all good work is based, that the publishers brought out their INDUSTRIAL SELF-INSTRUCTOR. And while, by the concurrent testimony of the critics, the work was pronounced to be one thoroughly practical, and eminently calculated to advance the interests of workers, it was particularly gratifying to the publishers and conductors of the work to find this testimony amply and sincerely acknowledged by many of its readers, who at once grasped and appreciated the principle upon which the plan of the work was based, and the spirit in which its various papers were written.

In presenting to the reader the first number of the *re-issue* of what is virtually a complete *Cyclopædia of the Technical and Industrial Arts of Great Britain adapted to Home Study*, it will be in his interest if a brief notice is here given of the important purpose which the work is designed to serve; of the principle upon which it is as a whole based; and of the spirit in which its papers have been penned; and which will be a useful supplement to the brief *résumé* of the leading subjects treated of, which we have already given. Holding the views its conductors do with regard to what technical education is, how it can be carried practically out, and the difficulties in the way of this,—holding further the opinion that the system or kind of technical education advocated by many will not do all that is claimed for it, and that something else very different indeed is required to enable us to meet the fierce competition which confronts us all over the world,—holding these views, the conductors of this work maintain this. That, not merely for the present, until a national system is carried completely out, but for all time to come, what is required in the way of a practical education, fitted to enable us to cope with the competition now forced upon us by nearly all nations, rests with the *individual* workman, combined with the *actual work* of the calling by which he gains his livelihood. And this *home study*, this *self-instruction*, will not interfere with, but, on the contrary, greatly aid and supplement, such educational help as the workman may receive at the hands of the teachers of such technical schools as may be established near and within easy reach of his residence. And this work, which we maintain rests with the worker or workman to do, as his part of the labour which nationally must be overtaken—this part of the mutual contract which must be made by the two great parties interested in this great question of *self-instruction*—must be carried on in the quiet and privacy of his *home*.

And to aid all those, whether as apprentices who have begun to learn, or as journeymen to carry on the work with greater or less ability and skill in one or other of the many branches of industrial work, is the aim and object of our work—the very reason of its existence. Carried on throughout, on the lines originally laid down, after the most careful consideration and a fair knowledge of the wants and necessities of the classes who live to work and work to live, the conductors, after the experience gained by the first issue, feel that they are entitled to claim for their Journal a practical value of a specially high character. It gives in a series of papers the practical details of the leading handicrafts and trades which go to make up by their production the vast wealth of the nation, as well as of the leading arts and sciences by which these are so powerfully aided, and upon the principles of which their practice is based. And this is done in clear and intelligible language, carefully divested of all those "learned obscurities of terms and theories" which tend much more to confuse than to enlighten beginners in the study of an art or a trade. These plain statements are aided by a profusion of illustration not often attempted, and rarely obtained to the degree which our pages display.

But to aid those who are determined to devote their spare hours, or a large portion of them—for wise recreation is as much a duty as study, and rightly carried out greatly aids it—to the work of *Self-Instruction at Home*, always satisfactory both in its mental aspects and in its pecuniary results, the conductors of the INDUSTRIAL SELF-INSTRUCTOR have had closely in view throughout its pages that mode of treatment of the subjects which, while it gives the reader a clear insight into its details, compels him, so to say, to *think and observe for himself*. The value of thought, of viewing a subject "all round," and the almost equally valuable habit of a close and intelligent observation of facts and circumstances bearing upon the points, cannot be overestimated. All the points here involved in thus thinking and observing, and of the highest import to the *student at home* busily engaged in the work of *self-instruction*, will be found fully detailed in the paper in the text entitled "The Workman as a Technical Student: How to Study and what to Study," to the attentive perusal of which the conductors of this work feel bound in duty to invite all of the readers engaged in *self-instruction*.

In strict uniformity with the great principle upon which the INDUSTRIAL SELF-INSTRUCTOR is based, in addition to the important points above named, the conductors would here draw attention to another point which has a very marked influence of a highly beneficial kind upon the successful work of *self-instruction at home*. This is the cultivation of those habits the observance of which are not only essential to secure success in the study, but also success in life. What these habits are, and how they act and re-act, alike upon the prosperity of working life and the perfection of home study, the reader will find fully detailed in the paper above referred to—"The Workman as a Technical Student." And throughout those papers dealing with actual work, especially in the branches of what is called "construction," the importance of attending to those habits above referred to will be clearly noticed, and is always implied.

But while the INDUSTRIAL SELF-INSTRUCTOR FOR HOME STUDY is designed to be specially useful to those actually engaged in daily work of one kind or another, its very title indicates that it will be useful to the younger branches *still at school*, and equally, though in a different way, to that wide class known as *General Readers*.

What has now been stated is sufficient to convey to the reader a fair idea of the character of our important work, the nature and wide extent of its topics, the spirit in which the papers are written, and the profusion with which all are illustrated.

TECHNICAL EDUCATION

IN RELATION TO

THE PRESENT CONDITION OF OUR INDUSTRIAL WORK.

CONTENTS.

Introductory—Peculiarities of English Work—Foreign Competition with English Work—Character and Extent of the Foreign Competition which English Work now meets with—Some Business Considerations connected with the Foreign Competition with English Industrial Work—The High Value of English Constructive Work—Practicality the Characteristic of English Technical and Industrial Work.

Introductory.

WE are essentially a nation of industrial workers. England has been called "The Workshop of the World." This description is emphatically true. It was our factories alone which for a long time clothed all the peoples of the globe—our iron and steel works which gave them their metals—our machine-shops which furnished them with their machinery, tools, and varied appliances. We for long, then, held the absolute monopoly of the world's work. We had no competitors, nor dreamed that we ever should have. But at length other nations have entered into a keen and close competition with us. But though this be so, and to a greater extent than many are willing to admit, it is still our country which is pre-eminently the grand workshop for all peoples. We are still the chief producers of the infinitely wide variety of objects, which minister alike to the material necessities and to the luxuries of varied populations in every quarter of the globe. It is our ships—a vast fleet of sailing and steam vessels—which carry them to each and bring back its raw products, which with our manufacturing skill we convert into objects of the highest value.

In endeavouring to account for this position which places us pre-eminently the first amidst the workers of the world, some writers have named one reason, some another. But it is not to one cause, but to several causes—and those of varied, but all of great, importance—that must be attributed the marvellous success which has hitherto placed us in the very front rank of nations as producers of all which man requires. Those causes still minister to that commercial wealth and commanding influence which makes us the envy of less-favoured peoples.

While it is true that we owe much to our isolated position —that "silver streak" which draws round our island home what some have called a "cordon of safety"—it is truer still that we owe vastly more to elements which are connected in the closest degree with our individual or national characteristics.

Peculiarities of English Work.

We are, as a people, not only indomitably industrious, but persistently persevering in all we undertake in the way of practical work. We have, moreover, a national taste for "adventure" which makes our engineers, mechanics, builders, inventors, our commercial men, and our tradesmen as bold in entering upon unknown and untried schemes as those brave navigators of old who discovered, and those soldiers who won for us and kept against the arms of the world that empire of ours on which the sun never sets. We are however, above all, a people having a natural taste for construction of all kinds—for what is popularly called the "making of things." And this lies at the base of almost every kind of work which has to be done. We are specially a mechanical people, as all colonising, adventurous peoples are; and above all this—and in this lies the main secret of our success—we are pre-eminently a *practical* people. We are none the less bold, though, in scheming or thinking out or looking for new fields of work. But in this scheming we scheme for a practical purpose. The aim and object of all our projects—however imaginative or sanguine they may at the outset appear—is that we shall make something out of them: in other words, that we shall make them "pay." Primarily, as giving us something useful in every-day work and life as individuals; secondarily, something which of necessity becomes practically useful to mankind in general.

Foreign Competition with English Work.

But while all this—and more than this, which might be named if space permitted—has done so much for us in raising us to the very first position as a wealthy and powerful people we have nevertheless been but too apt to believe that our system of working was perfect. And further, that competition from any quarter was a very unlikely thing to take its place as a power which might one day lessen our trade and injuriously affect our commerce. Notwithstanding, it has been in the minds of many practical and business men for long, that while we have been pre-eminently successful in the *making of a market* to which all the world came as customers, we might some day find that we had a difficulty to *keep* it.

Nor was this conclusion much to be wondered at. We have carried on—at least for a long period of years—a business which could in no sense be called secret or close. In the opinion of many, we have, indeed, if anything, been somewha too free in our teaching to other and foreign "peoples " the "mysteries of our crafts." Nor have we been less slack in supplying them with the very machinery and appliances to do the work the invention and possession of which for a long time gave us the exclusive power to make "all manner of things" for the markets of the world. But we have gone further than this. We have taught, and from the point of view of our own interests taught but too successfully, others to do the work which at one time it was we alone who could practically compass. We have also given them the use of our most skilful workmen, of our ablest managers. We have in these and in other ways directly and practically in one sense educated the people of other countries to be our opponents or rivals in production.

All this has very powerfully aided the desire which other nations naturally had, to produce for themselves those goods, for their almost complete supply of which they had for years been compelled to come to us. And, in proportion as they manufactured for themselves what they had before bought, so did they obviously require less from us.

But, not content with this qualified benefit, some nations have gone very much further. They have entered into a competition with us in order to wrest from us the trade of supplying peoples other than themselves. So keen has this competition become—with such audacity, so to say, is it carried on—that foreign manufacturers not only make goods for their own domestic supplies, but absolutely send them also for sale to our own markets. This, moreover, is done in many cases at prices with which we, with our high wages, cannot compete. So that the singular spectacle is afforded us of having, at our very doors, strong competitors with us in the production of goods of which we, at one time, were the only makers. And these come from countries which but a few years ago comparatively, were *wholly* dependent on us for a supply of these very goods which they can now make, and make so well as to be no mean rivals with us in our trade.

Some amongst us make light of these facts. But if their results are not now positively disastrous, they are, at all events, suggestive of a time coming when they may be so. And this, as some of our best authorities fear, to an extent not dreamed of even by those who habitually look to the gloomy side of things. But while by no means desirous to exaggerate either the nature or the extent of foreign competition—which we, as "makers" of all objects, are now face to face with—the wisest amongst us feel that it is too grave in its aspects to be set aside as a matter of no, or but of comparatively little, moment. One fact is certainly grave enough to make us as a nation consider seriously our position in this matter. In foreign countries, where but a few years ago a factory or workshop making the same objects we then almost exclusively made, could rarely and only at long distances apart be met with, there are now such places by the score. Whole towns and districts are in fact now occupied—and in many of them there are gigantic establishments—in the production of the very goods in the making of which we had that complete monopoly to which we have already referred. Nor can we easily arrive at any other than the logical conclusion, that precisely in proportion as foreign countries can supply themselves with the goods we formerly made, so will this affect—and in proportion lessen—our own production. But more than this: for in addition to a less than usual demand for certain classes of goods, we have to face the fact that some trades are leaving—some have almost wholly left—us, and are being now carried on largely, if not almost exclusively, in foreign countries.

Character and Extent of the Foreign Competition which English Work now meets with.

Those who have had opportunities given them during the last thirty years or thereabouts—to go no further back—of visiting various districts of the Continent, must have been struck with the truth of the statement made in our last paragraph. And if proof other than merely ocular, generally or practically, or as the result of more protracted observation and inquiry, were needed, it can be had, and of the most striking and suggestive kind, in the evidence collected from all sources, and those the most trustworthy, by the Royal Commissioners appointed to inquire into the whole subject of Technical Education, and whose report was issued at the time we were concluding this General Review for press. It is idle, and worse than idle, to exaggerate or overestimate the importance and extent of the work done in foreign countries, which, as having at one period been done absolutely exclusively by ourselves, is therefore practically lost to us. But it is equally idle, and much worse than idle, foolish in the extreme, to treat this foreign competition as a matter of little moment,' or as if, possessing at the present time a power which does bring about a loss to us, this power is in its nature only ephemeral,—so much so that it will in time be greatly overcome if not done wholly away with, when we shall once more resume our old position as the sole monopolisers of technical and industrial produce. It would seem absurd, looking at men and the circumstances surrounding them as they are met with in actual life, to take this latter easy-minded view of a matter of such vital interest to our country. Nevertheless, this optimist view, "whatever is is best," is held by many amongst us, and gives rise to that positive indifference which forbids a wise consideration of what the evil really is, and that practical neglect which prevents all attempts to get rid of it from being earnestly made. But it is fortunate for the nation that others, more important in point of influence if not in numbers, take quite another view, and do not ignore the facts which are before us, showing how great the evil is and what the extent to which work is done by foreign countries, which at one time we had, as we have already observed, the practical monopoly of. We have said that these facts have, to a greater or less extent, been long known to those who have an acquaintance with the circumstances of foreign countries. But they have been enormously added to by the labours of the Royal Technical Commissioners, to which we have above referred. Those have been formulated with such care, and recorded in the pages of their report in such a practical way, that the whole will form a text-book, so to call it, which will be a trustworthy guide to all those who desire henceforth to help forward the progress of National Technical Education.

How startling the array of facts thus now at hand bearing upon the work actually done by foreign countries, especially by those which are our near neighbours on the continent of Europe; and how great the loss which accrues to our country through a competition which, lessen it as we may in our estimation, must of necessity injure us as a nation of workers, a glance at some of the facts recorded in this Report of the Royal Technical Commission will clearly show. We have said that there are those who have made light of this competition, if they do not still treat it easily; others with sounder reason have feared that it might be even of greater importance than such facts as were up to the publication of the report at command would imply. But the wider array of those which the labours of the Royal Commissioners have made public, have had this result—that the extent of the technical and industrial work done in Continental countries—in other words, the practical competition they carry on with us—is proved much greater than they (the Commissioners) had reason to expect from such evidence as they possessed prior to their investigation being entered upon. The evidence they give in their report is of the fullest, and from this point of view eminently satisfactory. But from the practical or trade point of view, as it concerns us as producers, it is anything but satisfactory,—on the contrary, the facts are calculated to give us great and grave concern. An admirably concise and clear summary of those facts is given in a recent issue of the leading journal, the *Times*, which we cannot do better than reproduce here. "The modern industrial establishments of France, Germany, Belgium, and Switzerland are perfect in their kind. Machinery for various purposes, which is not excelled by our own, is produced on the Continent. In certain products requiring an intimate knowledge of organic chemistry—as in the preparation of artificial colours from coal tar, and in some new chemical processes—as in the application of strontia to the manufacture of their sugar (beet-root), Germany has taken the lead. Gramme's dynamo machine gave the first impulse to electric lighting; turbines perfect in design and execution utilise the water power of Switzerland; the German railway bridges and roofs are marvels of strength and economy of material, thanks to the mathematical knowledge of the German engineers, acquired in the Polytechnic School; and as regards the sinking and ventilation of deep mines, new methods or inventions have been perfected in Belgium. Mulhouse is pre-eminent in the production of cotton prints of the most tasteful design and the most perfect execution. Lyons excels in hand-loom silks of the most expensive kinds, and in dyeing and finishing tissues of the same material. Woollen yarns are spun at Verviers, from South American wool, and exported to Scotland. Basle has monopolised the trade in ribands; Crefeld is in a fair way to do the same in velvets; and Chemnitz is not satisfied with supplying the world with cheap hosiery, but is manufacturing mixed fabrics of wool, cotton, and jute for the markets of Europe and America. The finest merinos manufactured at Rheims are supplied to every capital, London not excepted. Railway material of every kind is sent from Germany to Spain, and from France to Italy; steel rails are exported from Belgium and Westphalia to every part of the globe."

Suggestive, and in many respects ominous, as this long list is, it would be easy to make it longer still, for in almost, if not absolutely in every department of technical and industrial work, foreigners are competing with us. And, if in this view we extend the field of inquiry to take in what are called minor trades, we find the same element of a direct competition with us, and which is more or less successful, carried vigorously on. We need not take up space by citing many examples of this, but as sufficiently illustrating the point, content ourselves by referring those who have the opportunity to make the inquiry, to the points connected with the supply of cutlery in Continental countries, say France, as it now is, and what it was not so very many years ago. At that period the only cutlery valued was of English manufacture, and of the trade we had the monopoly. But let an honest inquiry be made into the matter, and it will be found that now we neither possess the reputation of good makers, nor the monopoly which we so long enjoyed. The more widely the area of the field of inquiry is extended, the more unsatisfactory to us as producers will be its result—as showing that in many departments of industry of which, in times gone by, we were the undisputed masters, alike as to ability to produce the best, and in the markets which we monopolised, our position is in many cases already wholly, and in others is being very rapidly changed.

Some Business Considerations connected with the Foreign Competition with English Industrial Work.

Taking even the most favourable, or the most indifferent view of such facts as we have now named, and of others as powerful in their way, which we have suggested, we confess that it is not easy for any other conclusion to be arrived at than this: That if foreign peoples are supplying their own home markets with the goods of which we at one time were the only producers, just in proportion as they succeed in making what supplies their own home demand so must they require less of what we produce. And if, in addition to producing for themselves, foreign nations enter into the fields of trade existing in distant countries, of which we had also at one time the complete monopoly, thus closely competing with us, just in proportion as that competition is successful so must the extent of our supply be lessened. Now, such is our condition in relation to foreign countries. And although it is not easy to state precisely in how far this condition brings about the lessened business which we now do—in how far it is the cause of slack times in our manufacturing districts, leading to "short time" in our factories—it must be admitted that all this is more or less influenced, and that injuriously, by the competing traders of foreign peoples. To those who have had, and may now have, opportunities of travelling much abroad, and who moreover have at least a fair, if not a full, knowledge of technical and industrial trade, it is, we think, somewhat inconceivable, after thus seeing what these peoples have done and are doing in the way of establishing factories of all kinds, many of them as complete and large and some vastly more gigantic and complete than our own, that any one should conclude that all this does not concern us as producers.

Of the many Englishmen who have gone through the manufacturing districts of the Continent, and have visited some of its most interesting examples of fields of special work, a feeling has ever been predominant in the minds of the thoughtful amongst them, which has found expression in many ways, but which may here be illustrated in some such questions as these: "Here are workshops and factories numberless, employing daily large bodies of hands in the making of machinery of all kinds, in the manufacture of an endless variety of goods, of the system and the appliances of which we were the originators, or inventors, and of the products of which we were at one time the only makers and the only sellers. What is the reason—if there be a reason—why we have allowed all this trade, the employment of thousands of people, and the expenditure of millions of pounds, to slip, so to say, 'from between our fingers'? Or how comes it that we have allowed—if it be that we have permitted it—the very peoples who were at one period in their history, and that not so far distant, obliged to come to us to be supplied with the varied products of our national industry—just as much compelled by circumstances as were the people of Syria in olden times to go down to buy the 'corn in Egypt'—to enter the field of production of which we at one time were the sole possessors?" And following upon these questions, full of most grave suggestions, have come others, of which the following may be taken as an illustration: "Seeing in the various districts of the Continent we have witnessed abundant evidence of the, to us painful, fact that all this work has *somehow* slipped from our fingers, is there no way by which we can get it back again? Or if that be not possible, have we no power nationally to prevent other trades following in like fashion—*i.e.* to keep what we have already got?" It is just the frequency with which such or the like questions have been of late years asked by far-seeing and prudent men, who have had opportunities of seeing and knowing what foreign peoples have been doing, and have done, to take from us, or largely exercise a power of production which we for long held to be our own exclusively, which has given such a prominence to the question of Technical Education. This, no doubt, has been also greatly prompted and promoted by the too frequent recurrence of "bad times" in our manufacturing districts, or of slackness or dulness of trade in one or other or in all of our producing branches. And such questions, in place of being likely to die out—the fate of so many questions of public interest in times gone past—are by the very circumstances of our times, and position as producers, almost certain to be put forward with increased and increasing energy, demanding to be heard and thoroughly investigated to see if there be a favourable answer possible to them.

No doubt, in this, as in all other questions of public or social interest, extreme views in either and opposite directions are sure to be taken. We have the view of optimism, or that which believes all things to be the best and for the best; on the other hand, that of pessimism, or that which holds that all is bad and will sure to be worse. But in this, as in most cases, the middle course between those two extreme courses is much more likely to be the just and the accurate one. We are of those, therefore, who, refusing equally to take an altogether rose-coloured view of the situation, or a wholly dark and gloomy one, believe that while there is enough in the actual position of our technical trades to make us pause and rouse us to serious thoughts of the gravest kind, there is also enough to give more than the mere gilding of hope—which is often delusive and not always realized—a pretty fair amount of certainty that better times for us are in store. The belief that we still as producers hold a power of which no one can deprive us, if only we determine that no one shall—a power which can enable us not merely to hold our own, that which we now possess, but rightly exercised will or may enable us to recover much of what we have lost, to regain that which we at one time possessed—may still be held by us as justified by present circumstances.

What is this power? The reply to this carries with it matter of momentous interest to us as a nation of workers, and with it moreover—indeed, of necessity—much bearing on the general subject of this Review. A brief inquiry into its nature will therefore be of great utility here.

The High Value of English Constructive Work.

Those who have had opportunities to institute a comparison based upon personal inspection and practical investigation between technical and industrial work as carried on in this country and the different countries of the Continent, have, as a rule, arrived at the following conclusion. They have had abundant evidence from many districts of the Continent to how great an extent trades and manufactures are carried on, which at one time were practically monopolised by this country. Some details of this we have already given. They have seen numerous machines at work, which rank high as examples of mechanical design, while possessing considerable merit in point of construction. Those machines, and various appliances which are used in conjunction with them, forming part of the system of general work, are the direct products of Continental machinists. But in pushing inquiries further they are found to be nearly in all cases based upon machines which originated in this country, were invented by our own machinists, and owe all the excellence of their original working capabilities to the way in which they were constructed by them. This by every investigator well acquainted with certain specialities is seen at a glance, and is what indeed might have been from the first anticipated, seeing that the trades and manufactures to which they are subservient this country first originated, and of them we have had a long and absolute monopoly. In other cases, and over wide districts, the machines used are found not only to be of British design or invention, but also of construction, having been supplied directly by our own machinists. But in all such cases, the one feature which stands prominently forward is the superiority which such machines possess, not only in point of the materials employed in their construction, in their thorough stability or capability of long endurance in working, and the precision with which their work is done, but in the high mechanical finish of the whole. So prominent are all these features, that in works and factories in which mixed machines are in operation, the product partly of Continental, partly of British machinists, where any particular machines or class of machines are noticeable for their efficiency and workmanlike design and finish, they may with considerable certainty of accuracy be declared to be the product of British machinists, either in design or construction, or in both. This may not be so true now as it was but a short time back, for such has been the determination of foreign machinists—in Germany perhaps more especially—to come up to the high standard of British work, that, not content with copying design, they have in many respects come up close to us in accuracy and high finish in construction. But this is, at present at least, exceptional. The same peculiarity runs through all branches of machine-making, the machine tools, or machines which make machines, and in all classes of prime motors by which machinery of every class is driven or set and kept in motion. Nor is this peculiarity, which distinguishes all British work in machinery and mechanical appliances, less characteristic of other branches of our technical work—more especially those which come under the head of Building Construction, and the cognate arts connected with what may be called the interior furnishing of structures of all kinds.

Practicality, the Characteristic of English Technical and Industrial Work.

In instituting a comparison, then, between the features of English and Continental work—taking it all round—that feature which stands prominently forward as the pre-eminent characteristic of English work is its thorough "practicality." We have glanced in the briefest fashion at some of the developments of this. This skill in construction, aided as it is by originality in mechanical combination, or by what is otherwise called the inventive faculty, and which is also a characteristic feature of our countrymen, constitutes the "power" by which, beyond all question, we first gained our proud supremacy as the producers of the world, aided, as it is scarcely necessary to say, by our national habits and personal peculiarities, as well as by our favourable national circumstances. And this peculiar gift has, as we have seen, been made applicable to every kind or class of handiwork or of productive industry. Other nations excel us in the design and the details of execution of what is called "artistic" work; they can compete favourably with us in the matter of wages; they possess in many districts, equally with ourselves, all the material helps which are essential in mechanical and industrial work; but in this essentially valuable feature of "practicality" we distance them all. No one has been as yet able to wrest from us this power, although other peoples have developed it to so high a degree of comparative perfection that it has given rise to the gravest of doubts in many minds as to whether we shall much longer continue to maintain our supremacy as the practical workers *par excellence* of the world. We are, however, of those who prefer to believe that we can maintain this supremacy. We must, however, determine that we shall do so, and not grudge any effort required of us; least of all withhold through miserably mistaken notions of economy that pecuniary outlay which will be necessary to enable the workers of the future to be helped to the full by all those aids which science and art can bring to them.

FORM AND COLOUR IN INDUSTRIAL DECORATION (*see Text*).

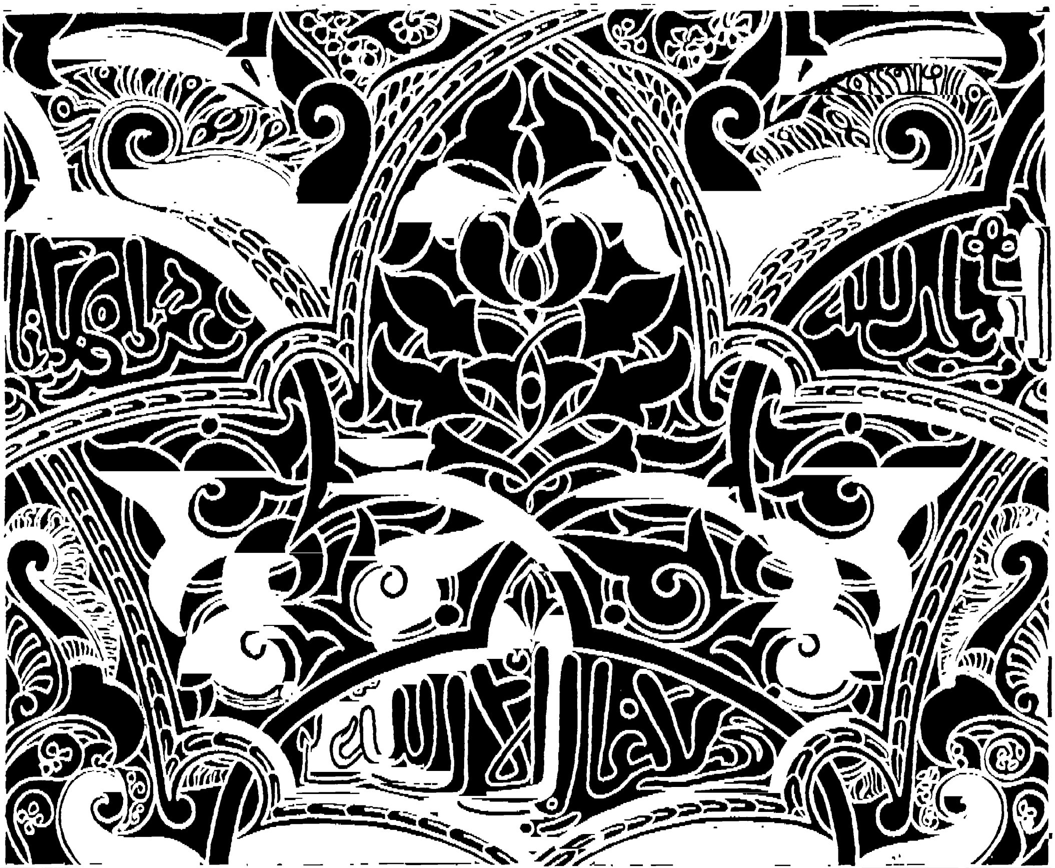


Fig. 1. Wall Decoration—style "Moresque" or "Arabic"—from a cast of a Panel from the Alhambra.

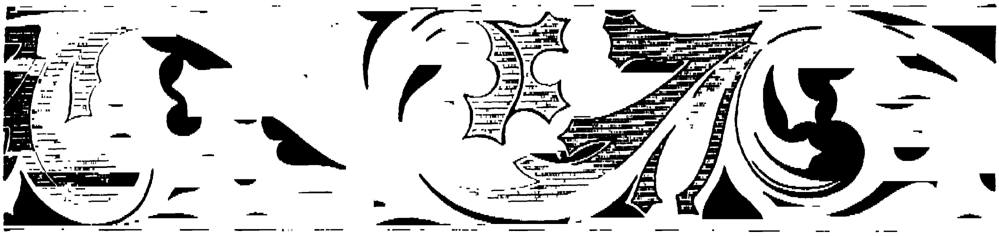


Fig. 2. Bands, Friezes, Mouldings, and Centre-piece.

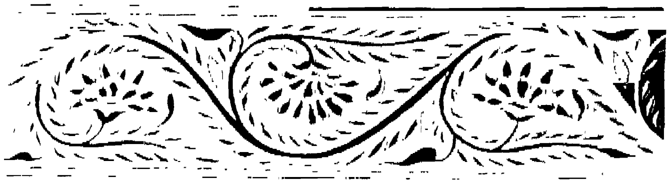
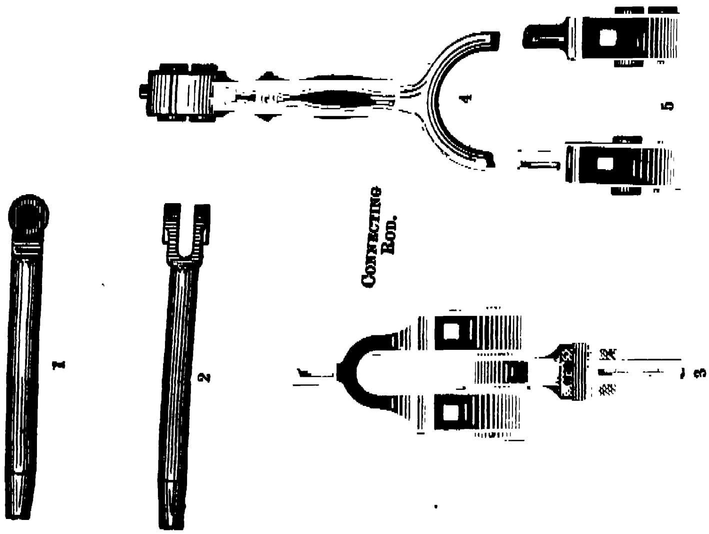


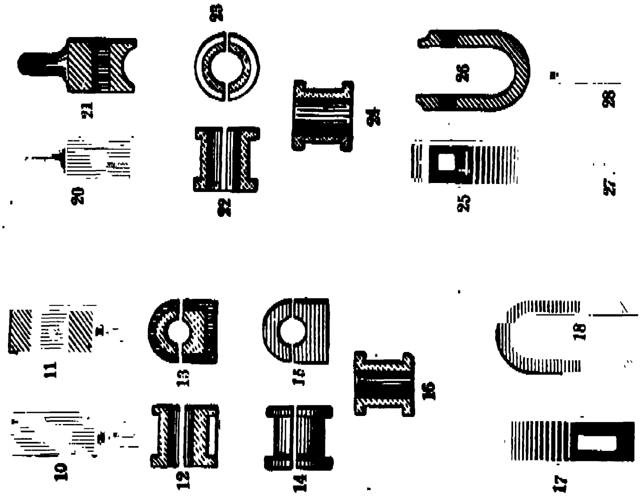
Fig. 3.

Fig. 4.

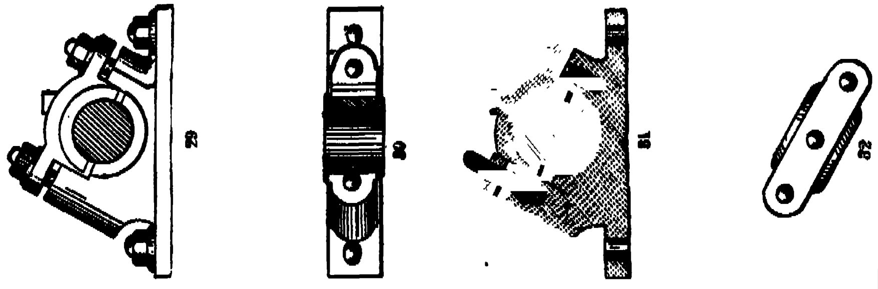
THE GENERAL MACHINIST *(see Text).*



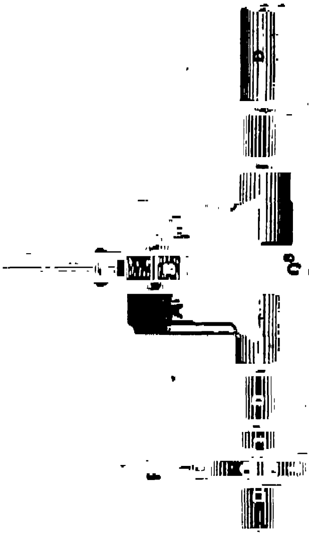
Connecting Rod.



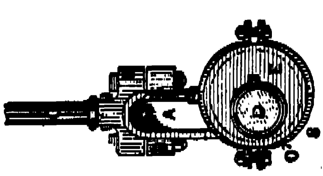
Details of Connecting Rod, Brasses, etc.

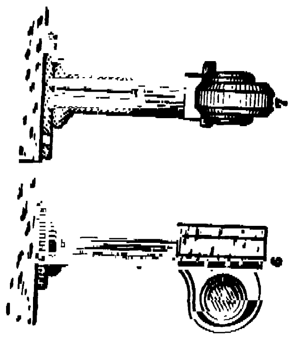


Pedestal, or Plummer Block.



Crank Shaft and Eccentric.





Hangers, or Gallows, for Shafts.

THE STONE MASON (*see Text*).

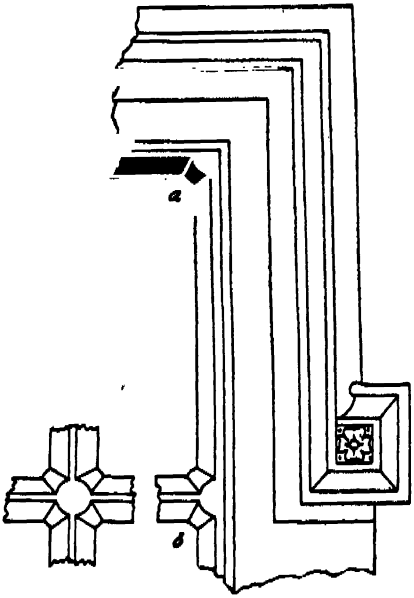


Fig. 1.

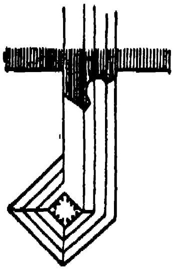


Fig. 2.

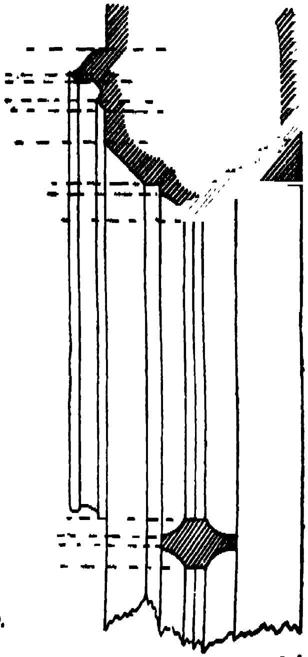


Fig. 3.

DETAILS OF WINDOW HEAD.

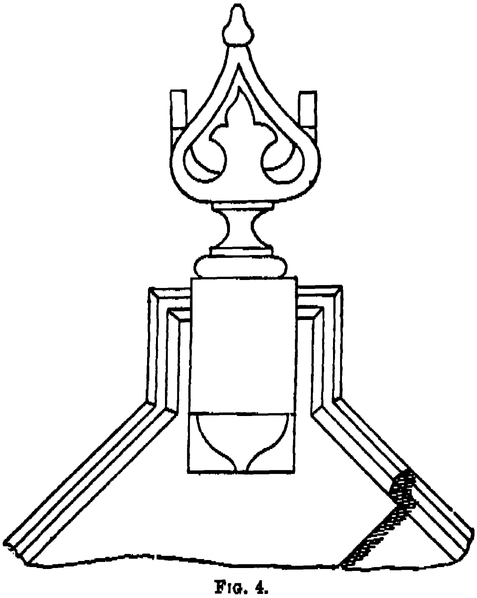


Fig. 4.

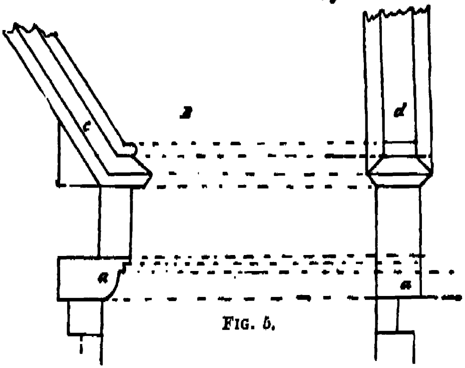


Fig. 5.

GABLE DETAILS.

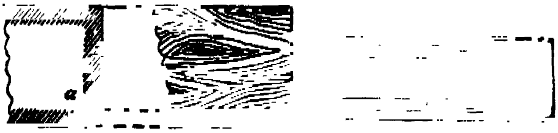


Fig. 6.

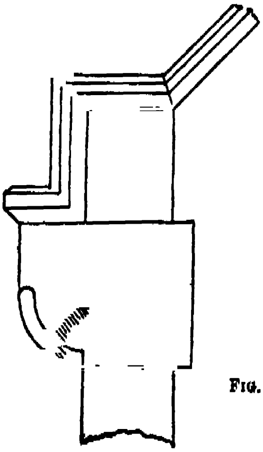


Fig. 7.

THE JOINER (*see Text*).

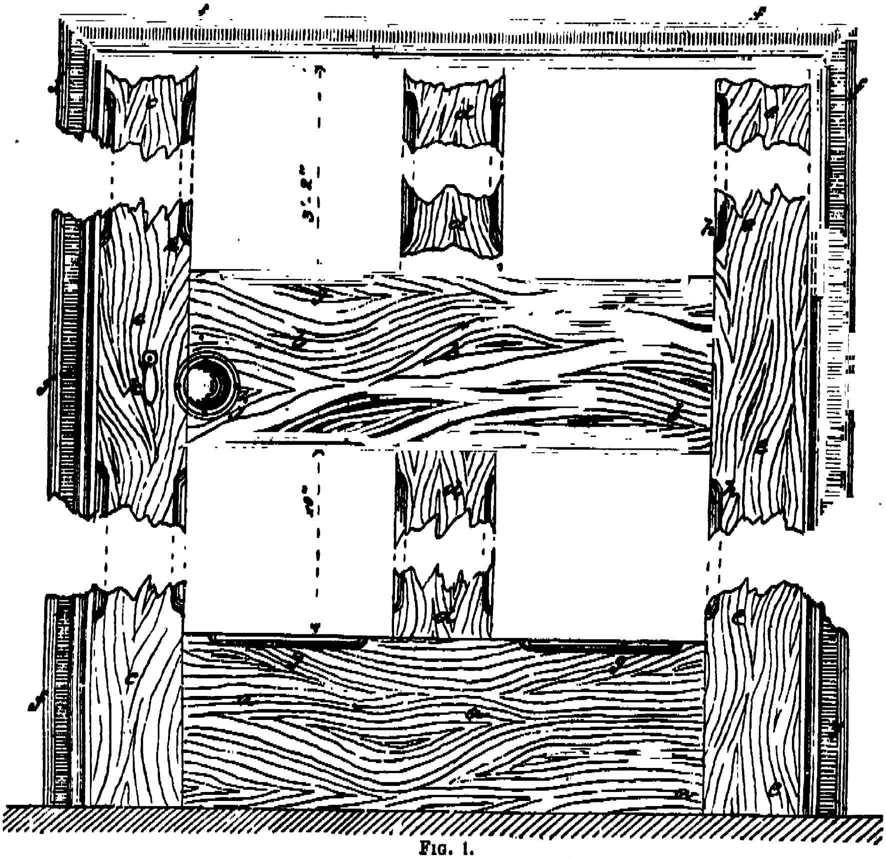


Fig. 1.

Part of Four-Panelled Door, and Details.

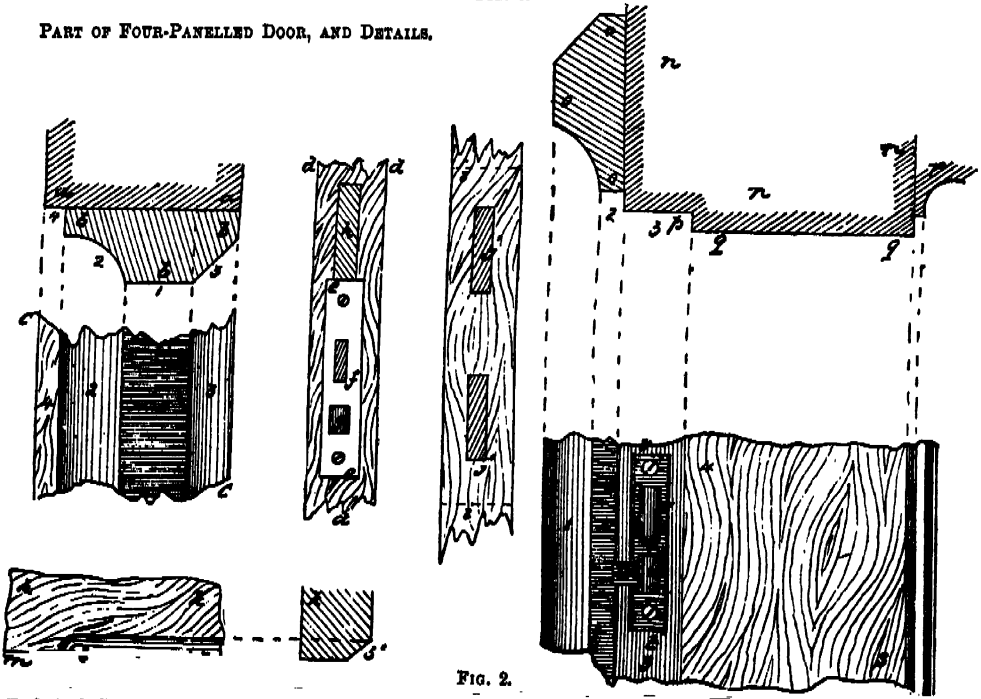
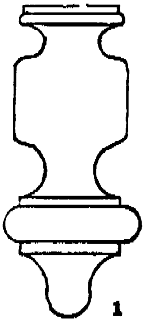


Fig. 2.

THE CABINET MAKER *(see Text).*

ELEMENTS OF CABINET MAKING.



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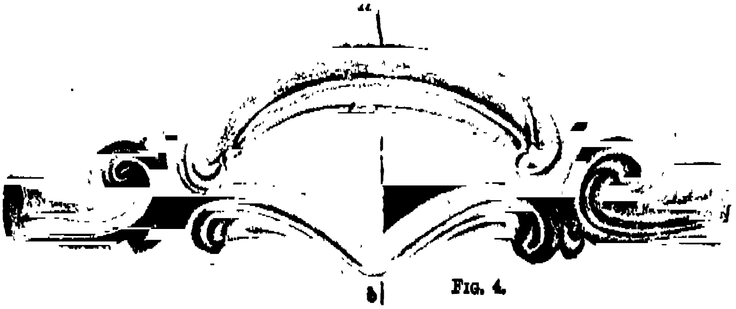


Fig. 4.

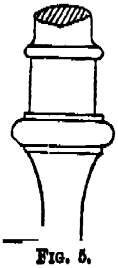
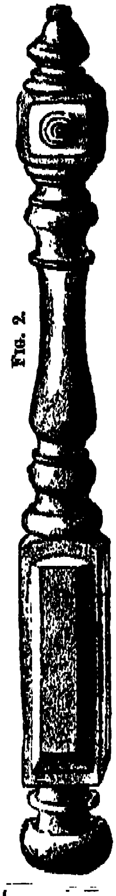


Fig. 5.



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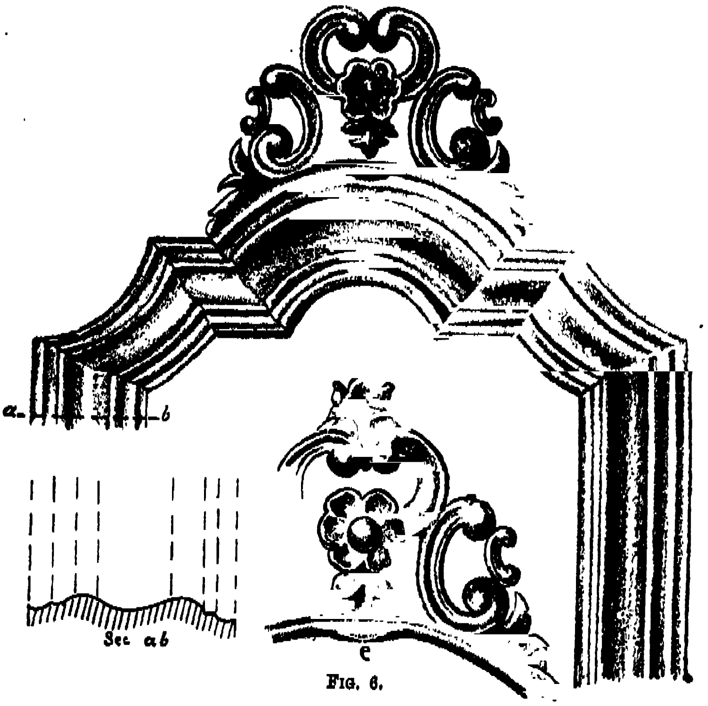


Fig. 6.

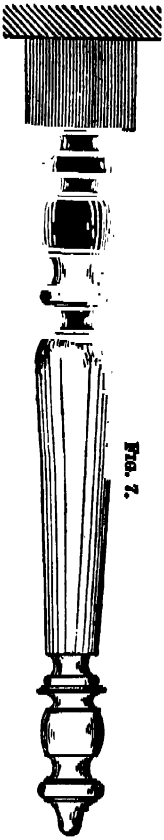


Fig. 7.

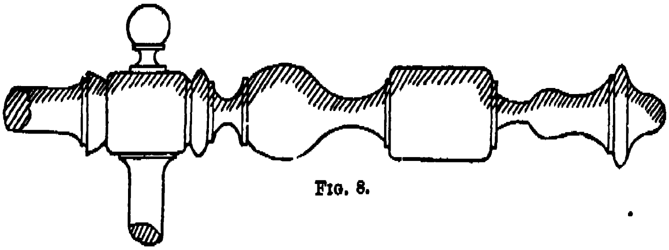


Fig. 8.

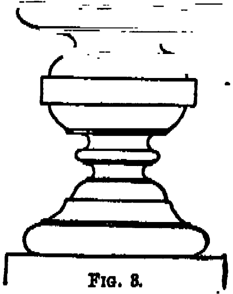


Fig. 8.

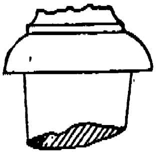


Fig. 9.

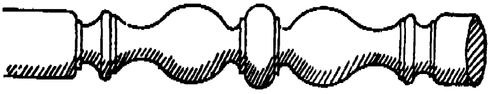
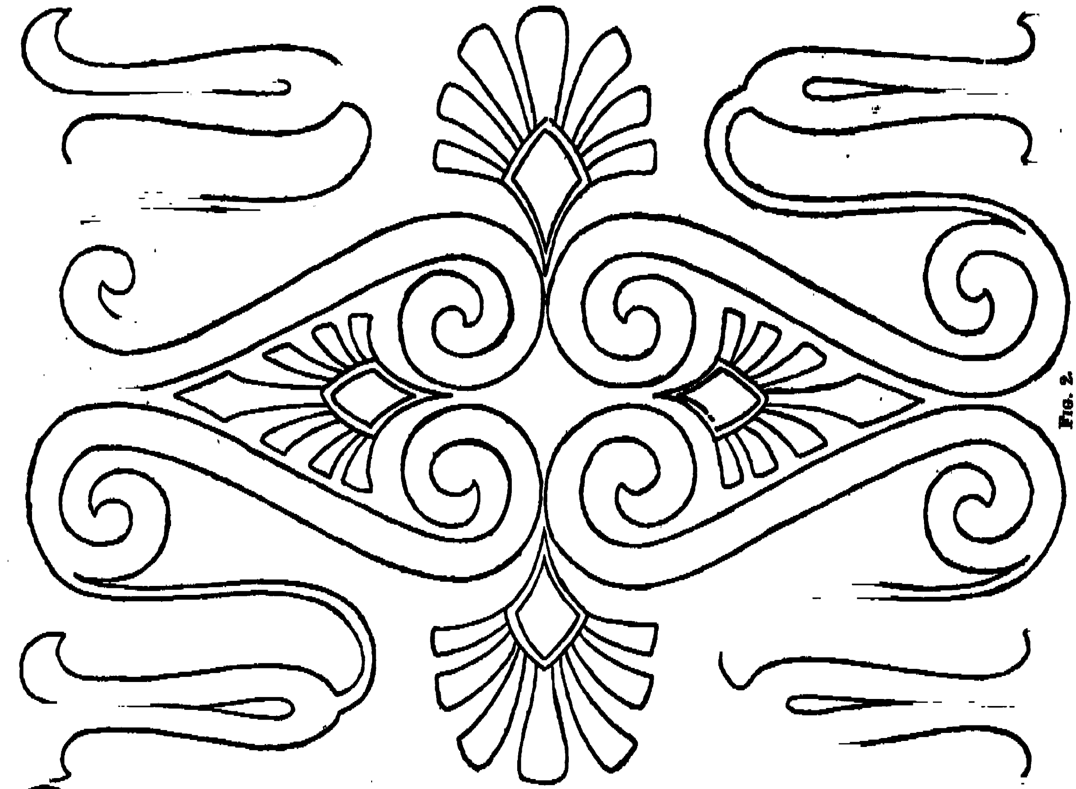


Fig. 10.

THE ORNAMENTAL DRAUGHTSMAN *(see Text)*.



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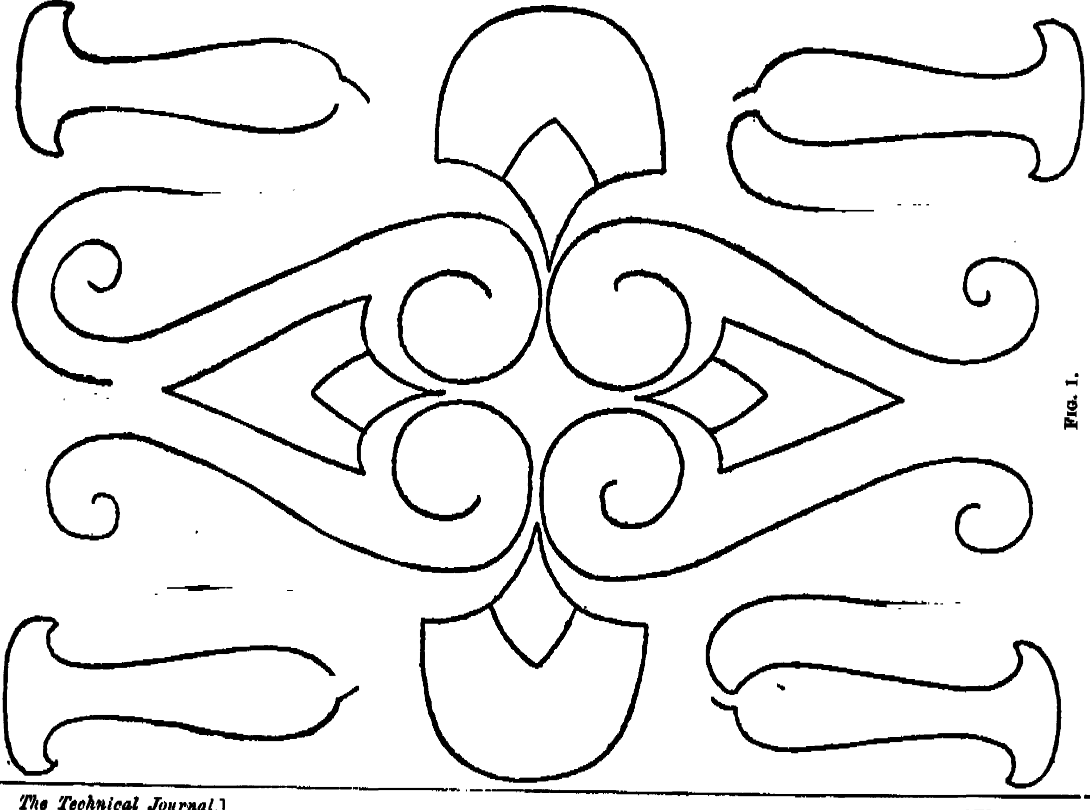
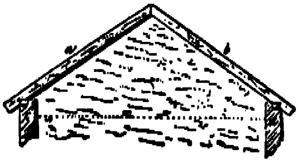


FIG. 1.



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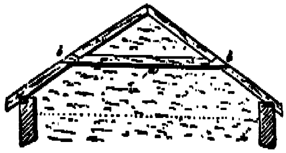
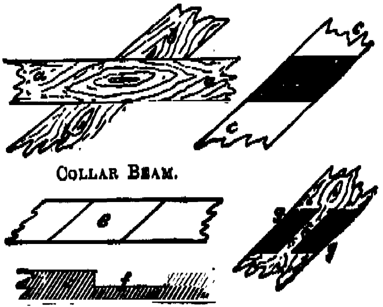


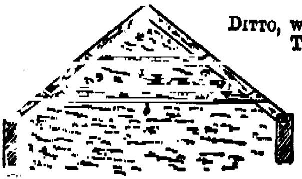
2

Span Roofs.



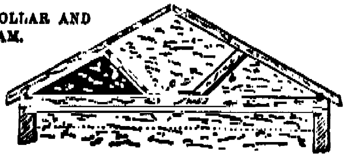
Collar Beam.

6



3

Ditto, with Collar and Tie Beam.



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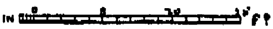

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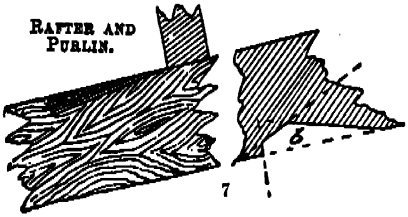
Rafter and Purlin.



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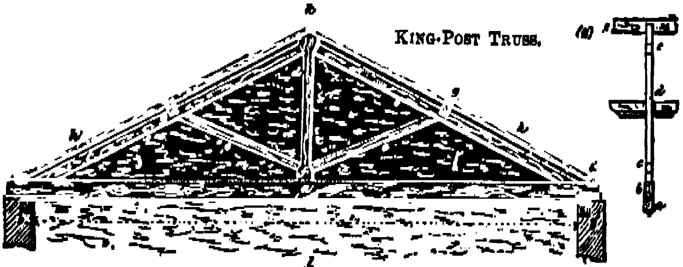
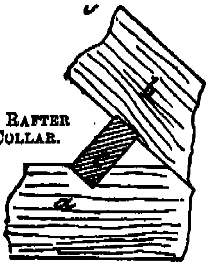


King-Post Truss.

9

Purlin, Rafter and Collar.



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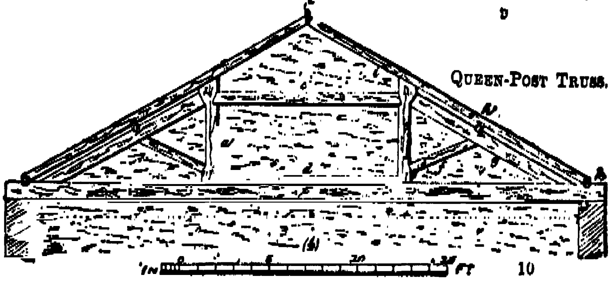

Queen-Post Truss.

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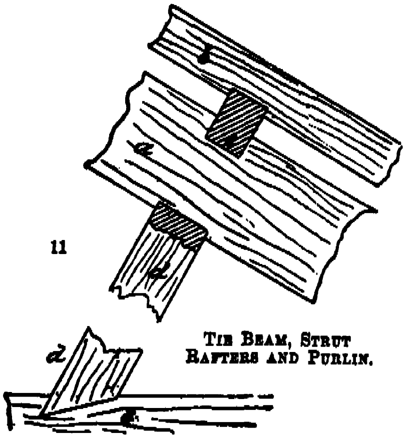

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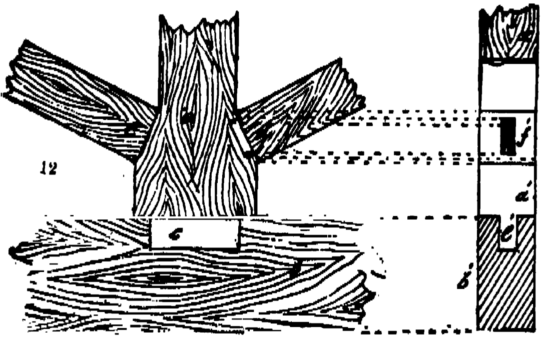
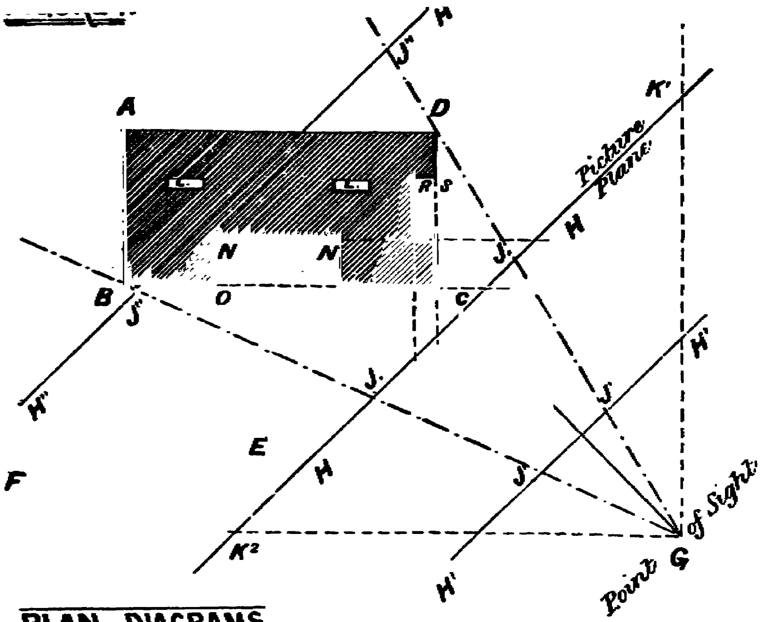
Tie Beam, Strut Rafters and Purlin.

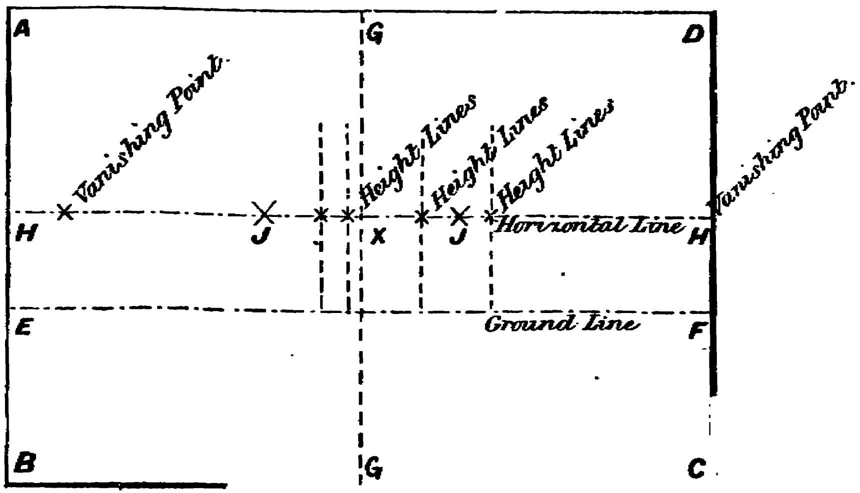


12

Junction of King-Post Braces, or Struts, and Tie Beam.

FIGURE 3 LAYING DOWN THE LINES OF THE PERSPECTIVE DRAWING OF A BUILDING FROM THE PLANS.





PLAN DIAGRAMS

FIGURE 2

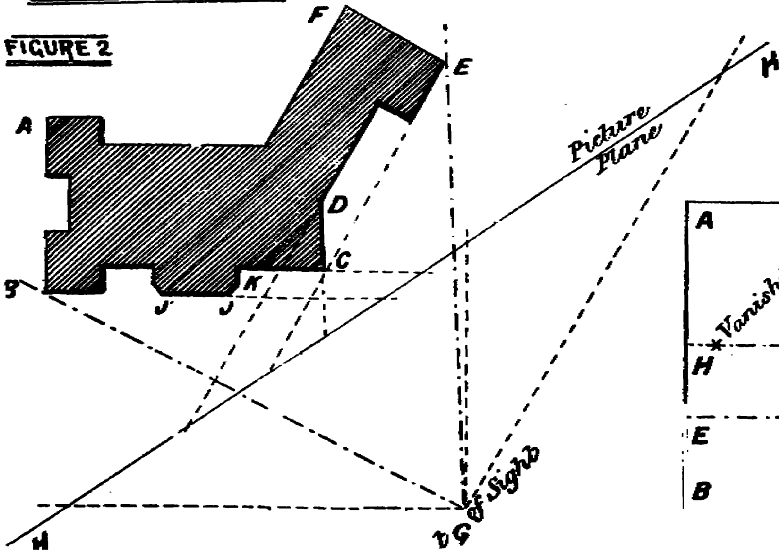
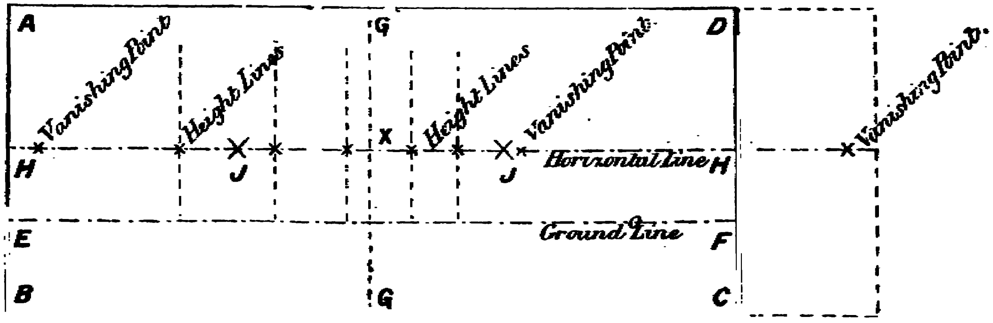


FIGURE 4.

ELEVATION DIAGRAMS



THE CARPENTER AND HIS TECHNICAL WORK.

Its Origin and Early Progress—The Principles and Details of its Practice.

CHAPTER I.

Introductory.

The carpenter claims for his calling, that if not the oldest, it is the most honourable of all. In the guild and other processions of the middle and the succeeding ages, and still in modern imitations of them, of which those got up with admirable *vraisemblance* at the fêtes of some of the leading Continental cities, especially of Belgium, are remarkable examples, the carpenters took the first place, claiming this in virtue of the sacredness given to their trade by the fact that our Saviour himself worked in a humble carpenter's shop in old Judæa. The necessities of shelter from the inclemency of the weather, or of protection from burning sun or chilly wind and rain, would compel man to put his wits to work, in order to devise the best means of securing it. At first the caves and holes of earth, the shade of overhanging cliff and rock, or of some secluded spot in bosky wood or dense forest, would suffice to meet his wants. But as his numbers increased, and with them a desire, if not for higher personal comfort, at least for greater security against marauding foe or plundering neighbour, special structures would be erected. These, if not possessed of much that would add to the personal comfort of their inhabitants, and far from coming up to even an approach in accommodation and construction to the poorest of our huts now, would at least have the great advantage of sheltering from the roughest of the winds or the heaviest of rains; and the then still greater advantage of strength to resist attack.

Timber the Earliest Material used in Construction.

The very abundance of timber, in those early days when lands were covered to a great extent with forests, would naturally attract attention to it. It was moreover the easiest to be used for constructive purposes, for it was met with in as wide a variety of shapes as in that of dimensions. And there is little doubt that the first habitations of men were composed of branches of trees roughly put together. But it was long before the art of working in timber had so far progressed that large and imposing structures could be erected with it. We can, without a great stretch of imagination, conceive of its gradual progress. At first, tools being of the rudest (possibly sharp-edged flint or shell for cutting, and heavy stones for breaking asunder) the very smallest branches, mere twigs, would be used; the interstices between them, fitted up, as they would be, in roughest fashion to form a shelter, being filled in with the smallest of twigs, or even leaves possibly, plastered over with mud or clay. But with better tools and growing skill the branches of trees would be severed from their parent stems, and these planted as posts at wider intervals, would give points of support, between which smaller branches would be placed, and between these the intertwined twigs and leaves as before. It would be some time before the huge trunks themselves could be made use of. No doubt, long before axes sufficiently sharp and strong to sever them could be available, fire was used to level the lordly trees of the forest to the ground; possibly also for long to separate them into manageable logs or lengths. But when tools capable of dividing, as saws, of cutting or slicing, as axe or adze, came to the aid of man, a new era in the art of working in timber would be opened up to him.

Tools used by the Carpenter.

The tools of the carpenter are but few in number, and to a great extent of extreme simplicity of character, as compared with the tools more or less elaborate in make, but in number considerable, which the requirements of some of the mechanical arts demand. But few as the tools of carpentry are, they have a history which, if only known to us in its full development, would be seen to be full of most suggestive incidents and of practical value withal. But of this we may be sure, that the progress of the art would be dependent on the progress of tool-discovery and tool-making. At first the work of the carpenter would be of the simplest; his tools by which that work was, so to express it, bounded or limited, being themselves of the simplest. The smallest-sized timbers—or rather, as we should say, trees—would be dealt with,—long, indeed, after the rudimentary structures we have already alluded to, which would be more correctly called mere booths, or arbours to use the popular term, were replaced by erections which could be classed under the more imposing name of structures. But these could not be made without tools. Tools, therefore, would be invented; and, as we have said, would naturally at first be of the simplest and lightest character, which could only do the simplest or the lightest of work. The subject of tools will be treated of under a special head, so we leave it for the present and pass on to

Carpentry as a Constructive Art.

Considered as a purely constructive art, carpentry differs from masonry, the chief work of which consists in providing structures of stone for the shelter and convenience of man as much by the nature of the materials which it employs as by the method of employing them. In stonework the stones are generally placed in horizontal layers the one above the other; their weight if they are cut, and the use of mortar if they are rough, or if there are any imperfections in cutting to be remedied, giving them the necessary stability. Thus are formed compact strong walls, broken only by such openings as are rendered necessary by the nature of the building. In putting up timber-work, on the contrary, a greater or less number of squared and properly cut pieces of wood, which can be inclined in any direction, are put together in such a way that the end of the one rests on some point of the length of the other, lending each other a mutual support. The pieces or members thus form light divisions, which have the advantage not only of great stability, but also that of being rapidly constructed; while the whole structure possesses a lightness which is sometimes necessary, and which stonework does not give. It is thus that the carpenter erects with remarkable rapidity houses and buildings of all kinds; that he divides them into stories in the simplest manner; that he builds bridges of all sizes; that he covers the largest buildings; and that his results, often preferable to those obtained from another kind of construction, are generally less expensive.

Some Technical Definitions connected with the Art of Carpentry.

In practical phrase we say that the pieces of timber forming any structure in carpentry are "joined" together, and the different methods of "joining" are in technical phrase called "joints." When two pieces are placed simply in contact with each other, we use the term—used also by the mason in similar circumstances of his materials—"bedded," or say that they "butt," meaning by those terms that the pieces of timber merely rest or press one upon another. When the pieces are connected by means of projecting parts and hollows and grooves the terms above named are employed, signifying that they are joined by what are called "joints." When a number of pieces are so connected firmly together, forming an arrangement designed to serve a special purpose, as a floor, a partition, or a roof, they form what is called in general terms an "assemblage," or more popularly a "framing" or "framework"; this having its special designation according to the purpose which it is designed in construction to serve. And this framing, framework, or assemblage, is arranged or designed in accordance with the principles of the science which dictate what the methods are of securing stability in the structure as a whole. Those principles come under the general title of the "principles of framing."

Proposed Method of Treating the General Subject—The Practice of Joining Timbers together, or Joints—The Theory and Principles of Framing.

We thus see that there are two departments of the art of carpentry, each of which, while it has its leading principle or principles, has also details more or less numerous. There are two methods by which the pupil can study the art as a whole, first engaging himself with the principles of framing, or what may be called the theory, and by some has been called the architecture of framework; secondly, taking up the consideration of the practical methods by which the timbers, their position and arrangement, have been determined by the design, and this based upon the theory of framing, and in practice worked out with the various joints deemed best fitted to secure the soundest mode of construction and the permanent stability of the whole. We have taken into consideration the general circumstances in which the majority of technical students are placed, and also those of many of our readers who are not directly engaged in industrial work, but still greatly interested with many of its details; and we believe that we shall best meet the wishes of the majority of those two classes of readers by taking up first the purely manipulative or handicraft part of the work of the carpenter—that is, the "joints" he uses in forming framework or framing—thereafter explaining the principles upon which that framing is designed.

The knowledge of the "joints" is very important, inasmuch as when we erect timber-work we should not put up a single piece, however useful it may otherwise be, without seeing beforehand how it will join with the others, and how we shall be able to work it out or practically execute it and put it in its place. Unless we do so, the projected framework would be impracticable. An assemblage of timber or framework, however complicated in appearance and however numerous be the pieces of which it is constituted, is, so far as the department of "joints" is concerned, always reducible to two pieces. After being joined the two pieces are then to be considered as one; and if a third piece be added to this, it does not constitute a joint of three pieces, as the pupil might at first suppose, but is obviously a new joint, and of which the feature is as said above—that is, of two pieces. The first piece, composed say of A and B, makes the one piece which we call C; the third piece, denominated D, makes up the assemblage; but so far as the "joint" is concerned of D, there are, strictly speaking, only two pieces, C and D. All joints, therefore, require, and only are concerned with, two pieces. It is the combination of pieces which form an assemblage or "framing," although parts of this may be made up of two pieces "joined," or of single pieces of timber only. The reader will perceive, therefore, that the practical work of carpentry—that is, the handicraft skill of the carpenter—consists, first, in joining pieces considered as simple members, and second, in arranging those different members so as to form a framing or framework; this form being dependent upon the character of the office it has to fulfil, or the purpose for which it is designed. And, as we have already said, in designing this framework or assemblage of single pieces or members, an acquaintance with certain physical facts is desiderated, and a knowledge of certain mathematical principles and geometrical constructions is further necessitated to make these facts available. This part of the subject may be called theoretical carpentry, and its features will be explained in due course in this series of papers, which concerns itself with carpentry as a whole. It might perhaps have been a more logical method to have considered the subject of theoretical carpentry in the first place, thereafter taking up the consideration of the methods by which the requirements of theory are met by the details of practice. But on due consideration we have deemed it most likely to help the pupil, whom we suppose to be for the present ignorant or nearly so of the subject, to arrive at a rapid knowledge of its practical details and principles or theory, if we take the details first. In illustrating and explaining these, much will be given by us, and we hope much will be acquired by the pupil, which will bear upon the theory and make its various points to be more easily understood by him. Having by this method of dealing with the whole subject a knowledge of what may be called the handicraft part of the work, he will be able to give, as it were, a concrete form to much of the abstract reasoning involved in the explanation of the theoretical principles upon which framing or framework is based. The first department, therefore, to which we direct the attention of the pupil is that of

Joints and Various Points connected with them, treated of in a number of Consecutive Paragraphs: General Character of Joints.

When two pieces of timber are to be joined, the relation they have to bear to one another determines the characteristic feature of what is technically called the "joint." First, the pieces may be at right angles to each other, in which case the joint is called a square joint; or the pieces may be so placed in relation to one another that the one is placed at an angle to the other, when the joint is said to be oblique, or is sometimes designated as a mitre joint, although this last-named joint is one of a special character, more closely relating to the work of the joiner than that of the carpenter; some of the work of the joiner overlapping, so to say, that of the carpenter, and *vice versâ.* The exact character of the term mitre joint will, therefore, be explained and illustrated fully in the paper entitled "The Joiner"; for, strictly speaking, a mitre joint is one in which the angle is invariable, and is used to join pieces which come under the first category named above—that is, of pieces at right angles to each other. In addition to the joints for pieces or members at right angles and those oblique, there is a third class in which a piece, constituting a single timber, is made up of two stouter pieces, the conjunction being formed by a particular class of joints. We have thus three classes of joints to consider; and of these we take up the first, which concerns itself with two pieces, one at right angles to the other. But before proceeding to take up the systematic description of the classes of "joints" and the numerous varieties under each class, we shall give, as introductory to the general subject, illustrations of what may be called representative or typical forms of joints under the classes we have named, together with sundry considerations connected with the general subject, and some remarks as to the way in which the joints were introduced, or, as we might put it, invented or discovered.

Representative or Typical Forms of Joints.

Fig. 1 represents the two simplest forms of the square joint named in last paragraph, in which the piece *a*, or member, is at right angles to the other, *b*. This will be described in detail when we come to the systematic consideration of all the classes of joints with their varieties. A much higher variety of joint of this class is illustrated in fig. 2, which represents

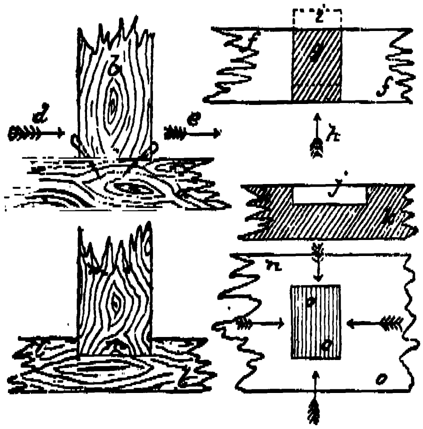


Fig. 1.

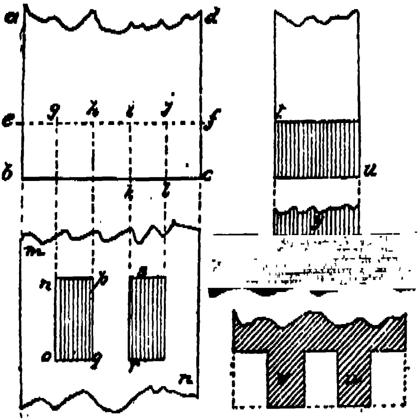


Fig. 2.

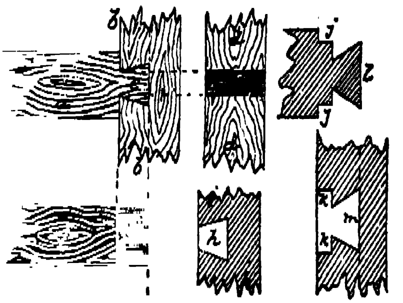


Fig. 3.

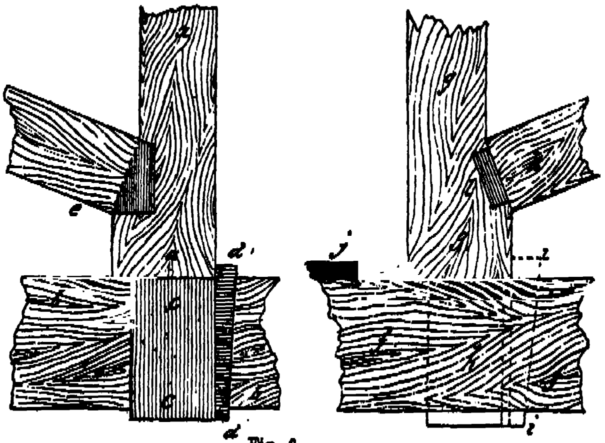


Fig. 6.

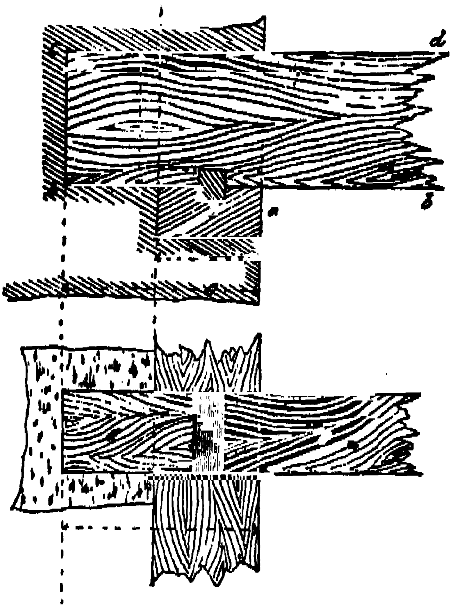


Fig. 4.

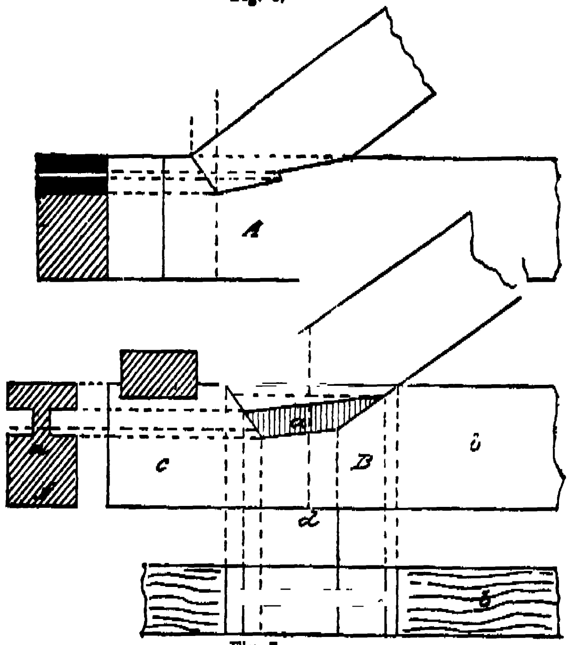


Fig. 7.

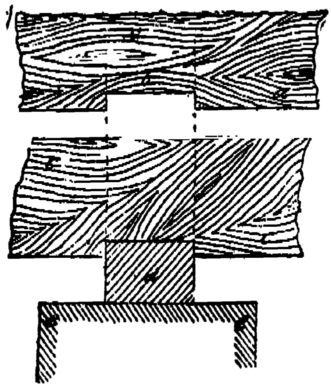


Fig. 5.

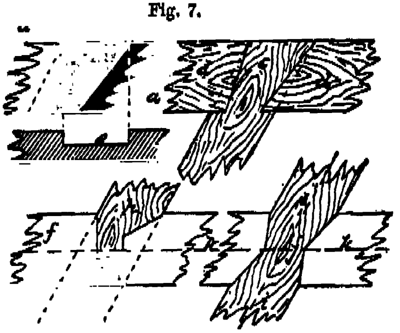


Fig. 8.

the double variety of the most important of all joints of the class, known as the mortise and tenon joint, of which more hereafter. In fig. 3 we give another variety of "square joint," in which one piece, as *a a*, is horizontal and jointed to the other piece, *b b*, which is vertical, at a given point of its length or height. This illustrates the form of mortise and tenon joint known as the dovetail mortise and tenon. In fig. 12, Plate VII., the reader will find another illustration of this class of joint, in which the king-post *a* is joined at right angles to the tie-beam *b*. More forms of joints of this variety will hereafter be illustrated. In those three varieties of the first class of joints, or "square" joints, figs. 1, 2 and 3, and fig. 12, Plate VII., one of the pieces is horizontal, the other vertical; but in fig. 4, while the two pieces are still at right angles to each other, the piece called the "wall plate," as *b*, runs at right angles to the line of "tie-beam," *a a*. Fig. 5 is another example of this variety of joint, in which the piece or "flooring joist," *c c*, crosses the "sleeper" plate *a* at right angles, but both are horizontal. Of the second class of joints, or "oblique joints,' we give an example in fig. 6, in which the piece or "strut" or "brace" *e* or *k* is oblique to the vertical piece or "queen-post" *a a* or *g g*. In fig. 12, Plate VII., another illustration of an oblique joint is given, in which the piece or "strut" *e* is joined obliquely or at an angle to the piece or "king-post" *a a*. Other forms of oblique joints are shown in figs. 8 and 11 in Plate VII. In fig. 7 we give another example of an oblique joint, in which the "strut" or "brace" of which the foot joint is at *a* is oblique to the "tie-beam" B. This will be described in a future paragraph. In the examples in figs. 8, 11, and 12, Plate VII., the oblique piece and the vertical piece both lie in the same plane—that is, their faces are parallel and run in vertical lines. In fig. 8 we illustrate a form of "oblique" joint in which both pieces lie in a horizontal plane. In the upper diagram the oblique member or piece *c* terminates at the outer edge of the piece *d d*. In the lower diagram the oblique piece *i i* crosses the other piece *k k*, so as to extend on both sides of it. In Plate VII., in fig. 6, an example is given of an oblique joint in which one piece, the "collar beam," as *a a*, crosses horizontally the oblique piece, namely the "rafter" *b b*. We now give illustrations (figs. 9, 10, 11) typical or representative of the third class of joints, in which a long piece—considered as one member—is made out of two shorter pieces. This method of joining is known generally as "scarfing." The simplest form of this class of joint is that known as the "half lap," illustrated in fig. 9. Fig. 10 is a true scarf joint, and fig. 11 another example. All the practical points connected with these joints and with other varieties, of which these are the typical examples, will be fully described in their appropriate paragraphs in succeeding chapters. Meanwhile we proceed to offer some remarks on

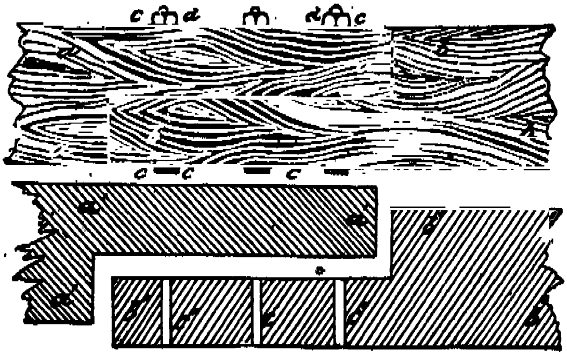


Fig. 9.

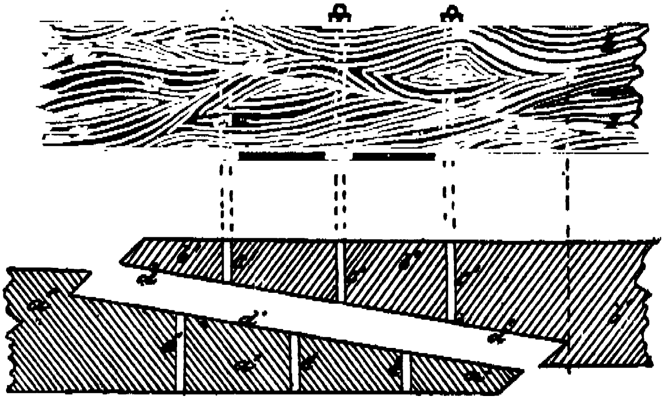


Fig. 10.

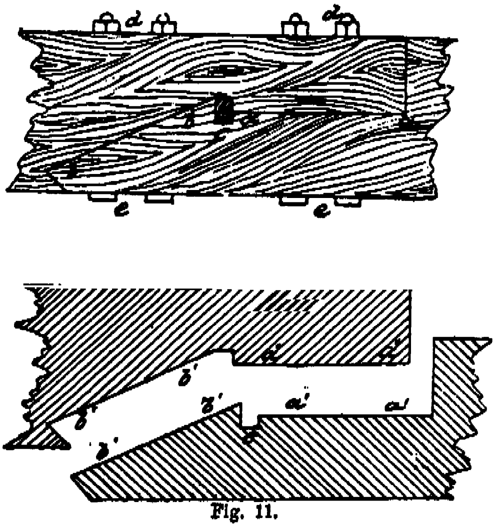


Fig. 11.

The Origin of Joints in the work of the Carpenter — Practical Points connected with the Subject.

Although some of the points connected with the origin of joints are more or less conjectural, still there is good ground for believing that the early work which led to the discovery of the joint as a feature of carpentry followed very closely the lines we shall presently indicate. But apart from other and obvious considerations connected with the subject, the youthful reader will possibly be led by what is given to see the practical advantages which will accrue to him in his after life from thinking out or over the various departments of his work. One of the shrewdest and most practical of our technical authorities has remarked that the great task before our industrial workers, and those who are being educated and trained to add to the ranks of these, is to learn to think, or in other words, to acquire the habit of thought. That this once established, there will be no doubt of future and further progress, as aids and helps of every kind, either in the form of technical classes or technical books, are at hand to lead the technical workers to exercise their thoughts in practically useful directions. And that there is a vast deal of truth in this dictum of our eminent authority, no one who knows what practical work is, and what workmen are, can have any doubt. Everything, therefore, which tends to cultivate this habit of thinking possesses a positively practical technical value. (See the series of papers in this work entitled "The Technical Worker as a Student—What to Study and How to Study.") We proceed, therefore, to the subject of the present paragraph—believing that our remarks will not only be practically interesting to the tyro, the beginner in the study of the art of carpentry, but we have some reason to hope that they will be of some suggestive worth to those who, while they are well acquainted with both its theory and practice, have not as yet attempted to trace to its origin the method by which both were arrived at, and by which the early labours of the carpenter were raised from the position of mere matter of handicraft skill and dexterity to the dignity of a science.

In proceeding to trace the progress of the art of carpentry, so far as it bears upon the general subject of "jointing," in some of its more special aspects, we have to notice, as already stated in an early paragraph on the tools of the carpenter, that in the erection of timber structures, those being for a long time confined wholly to domestic purposes, light timbers for obvious reasons would be used in the first instance. And this if for no other reason than that they could be more easily worked to the desired lengths and shapes by the simple tools then used, to say nothing of the greater ease with which they would be handled and placed in position. But in some instances longer and stronger pieces would be required for some special purpose than could be conveniently obtained or ready to hand. This would naturally lead to the consideration of methods by which the desired piece of a certain length could be obtained by the junction, in some form or another, of two or more of the smaller pieces at disposal; and thus the system of "joints" would be begun to be established. Joints at first would be of the simplest character, what one might call the rudimentary forms being only used. Thus we can conceive that amongst the first joints (so to call this simple arrangement) required would be a method of joining two short pieces together in order to make one single long piece. The easiest way to do this would be as roughly represented in fig. 12, in which the end of one piece, as *a a*, would be passed over the end of the other, as *b b*, the two being tied together by means of some simple ligature, as *c*; very frequently, as may still be seen in some semi-civilized parts of the world, some vegetable fibre or willow withes being used for this purpose. But this joint would depend for its strength wholly upon the strength of the bond or tie at *c*, and on the way in which this was tightly drawn and tightly secured. And at the best it would be a weak joint, the parts being easily moved from side, to side, as the touching surfaces of the two parts bearing upon one another would be of the smallest—namely, points or parts of a circle, as at *i* and *j*. To make them lie more "sweetly" together, to use a term frequently employed in mechanical construction, a broader surface would be requisite, so that there would be but little rolling or rocking motion one upon another: and it would take no great exercise of mechanical ingenuity to discover that flattening the ends of each, as at *d*, would be found effectual in this way. The two flattened surfaces would be placed together, and to prevent the tie from slipping off, a notch or two, in which part of it would lie, might follow.

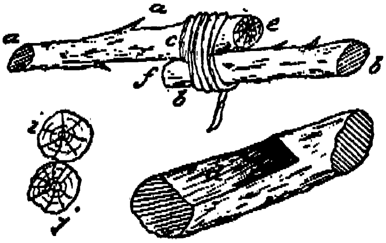


Fig. 12.

But this system of tying or binding two pieces of short timber together to form a single and longer piece would, even if the two were so securely bound together as to form a strong joint, be the clumsiest possible arrangement. The sense of the fitness of things comes into play much more early in man's civilization than some are disposed to admit; and this would show how awkward were the breaks in this form of joint, as at *e f* in fig. 12, even where the piece was to be used alone. Where timber lengths so joined were to be placed in juxtaposition, or resting upon one another, the awkwardness of the joint would be still more noticeable. We have shown how this joint, awkward as at the best it is, would be greatly improved by giving flat bearing surfaces, as at *d* in fig. 12, to the two parts placed in contact.

THE CALICO PRINTER:

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER I.

Introductory.

THE art of printing coloured designs upon cotton is in principle one of ancient origin, but only comparatively recently has it reached so high a degree of perfection that it may justly be classed along with the "fine arts." Perhaps no branch of industry has a more intimate connection with complicated scientific principles, the laws of mechanism, and the work of the artist, than that in which we are about to engage ourselves; and these are combined in so high a degree of perfection in this one industry as to form an art almost unique in its character. In no branch of industrial art are the ingenuity and resources of the operator put to a more severe test, whether as regards practical details or the even more puzzling chemical problems. And our readers need hardly be reminded that a subject so extensive both in its practice and theory can only be treated in such a manner as to present its general features, rather than the numerous details only to be acquired by experience in the print-works, such as the writer of this paper has had. Yet if the reader will carefully follow us, we hope to show him, as indeed our title indicates, what the principles of these wonderful processes are, and of the sciences upon which they are based.

Calico Printing in Relation to Chemistry.

The process of dyeing, or the permanent application of colouring-matters to fabrics, is of a chemical nature. *Dyeing* may be defined as the imparting permanent colour to a textile fabric through the entire fabric, so that both its surfaces may be uniformly of the same colour or shade of colour; but *Printing* is the art of dyeing in any desired pattern or design, although colour is often also "printed" uniformly on one side of the cloth. The art of calico printing consists, then, in dyeing certain parts only of a fabric in one colour, or in a combination of colours, so as to produce a design. Hence what we say concerning the *theory* of dyeing applies equally to that of printing. It must also be borne in mind that the precise chemical reactions that take place vary more or less with the colour. We now come to the consideration of the first principles of the calico-printing process.

General Principles regulating the Deposition and Fixation of Colour on the Surface of Calico or Cotton Cloth.

It will be easy to decide what are the chief qualities required of a colour which is applied to a cotton fabric in order to ornament it. In practical life, if the fabric so ornamented is to be exposed to the usual influences around us—such as friction, the air, light, water, etc.—the colour must be able to resist more or less perfectly the action of such agents, in order to constitute a "dyed" fabric.

This ornamentation of cotton in permanent colour is accomplished in a variety of ways. In some few instances colouring-matter dissolved in water will "dye," without any other means being resorted to than dipping the fabric in the solution: the colouring principle seems to unite chemically with the fibre, and so become fastened to it, or *fixed* as it is termed. Such is the case with aniline-red upon wool, silk, etc. In other cases the colour, or ingredients necessary to form it, are applied to the cloth either in a soluble or insoluble state, and afterwards rendered insoluble or otherwise fixed. In the case of some colours the *fixing* is executed in a simple and effectual manner; in others it requires many separate processes. Some colours fulfil to perfection the qualities required of them to be durable in practical life—such as complete insolubility in water and soap suds, and resistance to the action of light and air: such colours are said to be *fast*. Different colours fulfil in different degrees these desirable qualities: some colours are "faster" than others, according to the colouring-matter, mode of fixing, etc.; and the resources of the calico printer are constantly taxed to produce his colours as fast as the occasion or purpose demands. Many colouring-matters are of little or no service in dyeing and printing, simply because they form "loose," though beautiful, colours.

Colours used by the Calico Printer.

The colours imparted to textile fabrics by the calico printer's art consist of chemical compounds which are frequently of too complex a nature to permit of their exact composition being well understood. With few exceptions, as above mentioned, the fibre simply holds the minute particles of colour and displays them to advantage; being no component part of the colour. The *cause* of the colour of these chemical compounds, and of all bodies, lies in the composition of light itself. Light as received from the sun has inherent in itself the potency to produce all colours. Light is composed of three primary colours—red, yellow and blue—which by combination among themselves form violet, indigo, blue, green, yellow, orange, red, which again by an endless series of combinations in different proportions form every other colour. A body that appears *blue* is one that has the power to absorb and so destroy all the colours of which light is composed except blue; and so also other bodies are *red* because they absorb all the colours of the rainbow except red; and similarly with every other colour and shade.

The Two Classes of Colour used in Calico Printing

Most colouring-matters, as applied to the ornamentation of cotton fabrics, fall under one of two classes.

In the first class are included ready-formed colours which are insoluble in water when applied to the cloth, and are afterwards made to adhere firmly to it, or in other words are "fixed," without altering the nature of the colour as first applied. To this class belong ultramarine, vermilion, and lampblack. In the second class the colour, or part or all of the ingredients necessary to form it, are applied to the cotton in a soluble state, either mixed together or applied separately and afterwards made to form the desired insoluble colour,—or it is fixed. In this case that part of the colour which effects the fixation of the colouring-matter is frequently a metallic salt or tannin, and is called the *mordant*, although, strictly speaking, it is generally simply a component part of the colour. However, although this is a convenient division for a large number, it does not include all colours, since the theory, as well as the practice, varies with the colouring-matter. Moreover, the same dye or colouring-matter may form differently coloured insoluble compounds, according to the mordant, the treatment, the fabric, and other conditions.

General Principles of Dyeing, or the Imparting of Colour to the Fibres or the Surface of Calico.

The question "what is the theory of dyeing?" is not easily answered; nor indeed do scientific authorities on the subject agree as to what really takes place in every case of dyeing. To fully explain the action, as in the present state of our knowledge we understand it, would involve questions of physics; but for practical purposes it will be sufficient to indicate roughly the general principles. The colouring-matters which we apply to cottons in dyeing or printing may be deposited in the cloth by the following methods.

(1) *Colours fixed mechanically: Pigment Colours.* The colour is applied to the cloth in the form of very fine powder, mixed with a glutinous substance capable of becoming by subsequent treatment solid and generally insoluble, and so holding or adhering to the cloth, as well as firmly retaining or "fixing" the colour. Examples: Ultramarine, lampback, chrome green—fixed by albumen, which is soluble in cold water, but becomes insoluble and solid by the action of steam, etc.

(2) *Colours formed by the combination of colouring-matter with the fibre.*

a. When wool is dipped in a solution of the colouring-matter, a chemical combination of fibre and colouring-matter takes place. This is, however, not applicable to cotton fabrics.

b. The dissolved colouring-matter is mixed with an agglutinative material or *thickener*, and printed, and the union of colouring-matter and fibre is effected by exposure to steam.

The Classes of Colouring-matter formed in the Fibre without Combining with it.

a. The colour held in solution by a very feeble solvent, some kind of attractive force exercised by the fibres withdraws the colouring-matter from the solvent and precipitates it upon the cloth. Examples: Indigo, annato. The action may be considered to be analogous to the precipitation of salts from a "supersaturated" solution by simply throwing in material such as dust, or a fibre of cotton.

b. The colouring-matter is dissolved, but having no affinity for the fibre alone, combines with a mordant—as iron—which has been previously deposited in the fibre in an insoluble state; the compound which is then formed being firmly fixed in the fibre. It may be of an entirely different colour or shade to that of the colouring-matter as first applied, or it may be unaltered in colour. Examples: Alizarine (yellowish colour) and alumina give a red; alizarine and alumina and iron give chocolate, etc. Logwood (red-coloured) and iron give black.

c. The colour is formed by oxidation of colouring-matter, or matter capable of being converted into a colour, after deposition in the fibre. The colouring-matter is applied to the cloth in the state of solution, and is then submitted to a process of oxidation, which forms the desired colour and simultaneously fixes it. This oxidation may be effected in various ways—by exposure to air, exposure to some oxidizing substance such as a bichromate, or by adding to the colouring-mixture printed on, some oxidizing substance which on exposure to heat gives off oxygen.

d. The colour is the result of a chemical action taking place between two substances one of which is applied to the cloth, and the cloth is then passed through a solution of the second substance—whereby the desired colour is formed. Example: Iron buff or oxide of iron.

e. The *materials* necessary to form the colour are all applied to the cloth in a state of solution, then are made to unite together by subsequent treatment—as exposure to air, steam, etc.

The above classification is that adopted by Mr. Crookes, F.R.S., and other well-known writers on the subject. Although it includes most colours, and those most commonly used, there are many more which do not come under any of these heads, and are fixed by special means.

The Principle of Printing Colours upon Calico, as distinguished from Imparting Colour by Dyeing.

In every case of printing, there must be a design engraved upon wood or metal to print either part or all of the constituents of the colour. In many cases this is all that is necessary; while in many instances other processes come after or before the actual printing—such as dyeing, etc. The operation of laying down the design upon the fabric is accomplished in the following manner:—

One of the following is "printed" on the cloth, at *some* stage of the work—that is, applied to certain parts of the cloth so as to produce a design. Either (1) the entire colour, whether dissolved in a medium or not, or (2) one of the constituents of the "colour," or (3) some substance that will act upon (such as destroying) the colouring-matter when afterwards applied uniformly over the cloth, or (4) some other medium which will in some way or other cause the colour when applied to go to certain parts only of the cloth—indicated by the design. This effects the deposition of colour in certain parts so as to form a design. This "printing" of some substance on the cloth may be done in two ways,—by block or hand printing, and by machine or cylinder printing. The first method is that which was universally employed before the invention of machine printing. The design is cut out in relief upon blocks of wood, the raised parts, *i.e.* the design, being coated with a colour, or different parts of the raised design coated with different colours. The block is then placed upon the cotton by manual labour, or mechanically, thus leaving a coating of colour on the cloth corresponding to the design on the raised parts or embossed surface of the block. In order to render the colour thick enough to adhere in sufficient quantity to the block and to the cloth, as also to keep it from spreading, it is thickened with such substances as gum, albumen, etc. The colour is allowed to dry, and if necessary is afterwards developed by subsequent processes. The colour being then fixed, the thickening may or may not be washed out, according to the nature of the colour. This kind of printing by hand is fast going out of use (for very obvious reasons), except for a few colours that cannot so well be printed in any other way. In machine printing the colour must also be thickened; many substances being employed for the purpose—chiefly starches, flour, gums, and albumen. It is applied to the cloth by means of a copper roller engraved with the design in lines cut out of the metal, which revolves in a box containing the colour, the excess of colour and the colour from the smooth parts of the roller being removed by a plate of steel adjusted against the roller, and so "scraping" the smooth parts and leaving the colour lodged in the little ridges of the engraved surface; the roller, passing over the surface of the cloth, parts with the colour which is lodged in the engraved part—the smooth parts being quite free from colour. All this is done by a machine which in its perfect form rivals the most ingenious and accurate pieces of mechanism of modern industry. One colour or so many as twenty colours may be simultaneously applied by one machine, the construction of which will be described further on. The development and fixing of the colour is subsequently effected in different ways; the printed goods are subjected to the action of steam, the air, various liquids, or some other agent, which develop the colour. The colour being fully developed and fixed, any subsidiary substances, thickening, etc., used in printing are removed, and finally the goods are "finished,"—starching or weighting or giving a smooth to the surface as the case may be. Although we have, in order to give a general conception of printing, reviewed the process in a few sentences, the various details of the machinery and its management are of the most complicated nature, and only by long practice—or "apprenticeship"—does a man become proficient in his art.

As the reader will have learned from the above, there are many "styles" of printing, or different methods and processes for making different combinations of colours. To this subject we have specially devoted a division of this paper.

Before proceeding to describe in detail the various operations which the calico has to undergo before its surface can be ornamented with a coloured design, it may be well first to mention the successive processes: (1) such preparation of the grey calico as shall render it fit for printing upon—principally by "singeing," or burning off loose hairs, etc., and by bleaching; (2) the preparation of the colour or composition used in printing; (3) printing the colour, and in some cases subsequent dyeing; (4) developing and fixing the colour, and in most cases subsequent improving of the colour by washing with soap, etc.; (5) finishing.

First Process of Calico Preparation for Printing—Singeing, or Firing.

The grey calico fabric, as it comes from the hands of the weaver, if placed on a level with the eye, exhibits numerous loose cotton hairs, or flocks, projecting above the surface. These, if not removed, would in most cases prove injurious in printing by blurring the outline of the design and interfering with the deposition of the colour. The first process in the operations of calico printing, therefore, is the removal of these cotton ends. This is effected by one of three methods: singeing or firing, shearing, and a combination of both of these methods. Shearing alone is not often employed; singeing is the method most commonly adopted.

This may either be done by means of red-hot plates, or by a flame, or by a combination of both. The latter method is that now generally adopted. The calico passes through the upper part of a series of long gas-jet flames, and then over and in contact with red-hot plates, with such velocity that the loose cotton ends are burnt, while the fibre of the calico is not injured.

In one form of machine the coal-gas for burning is made by the machine itself, from a cylindrical retort filled with coke and coal heated by the same furnace that heats the plates; the coal-gas generated is burnt almost as soon as it is formed.

Fig. 1 is a diagram partly in section of the singeing machine: *a a a* is the furnace, built of brick and lined with good fire-brick; *e e* is strong brickwork supporting part of the top of the furnace; *f*, *f*, are the curved iron plates which are made red-hot by the furnace beneath, and *h* is the series of gas-jets from a pipe *i*, which conducts the coal-gas either from an external source or from a retort immediately below *i*, heated by the furnace *a a a*. The heap of calico, *u*, is drawn up and across the guide *v*, then between the square wooden rods, *w*, *w*, so as to make the cloth smooth. It enters the machine through an opening at the side, between A′ and *i*, passing through or in contact with the flames *h*, then it passes over and in contact with the two curved plates *f*, *f*, and passes out over the roller revolving in a box containing water. It then passes over the roller *k* into this box under the roller *l*, then out of the water, and passes between the rollers *m n*, where the cloth receives the motive power to draw it through the machine. The top roller, *n*, is larger than the bottom one; the lower one being turned by a small engine, the top one being pressed down upon the under roller by a weighted lever at *o*, thus giving the cloth the necessary "nip" to draw it through the machine. The calico then passes upwards and through the porcelain ring, *n*, so as to bring it into the rope form, in which form it passes over the wince *s s*, and falls into the barrow *t*, in which it is wheeled to the liming machine.

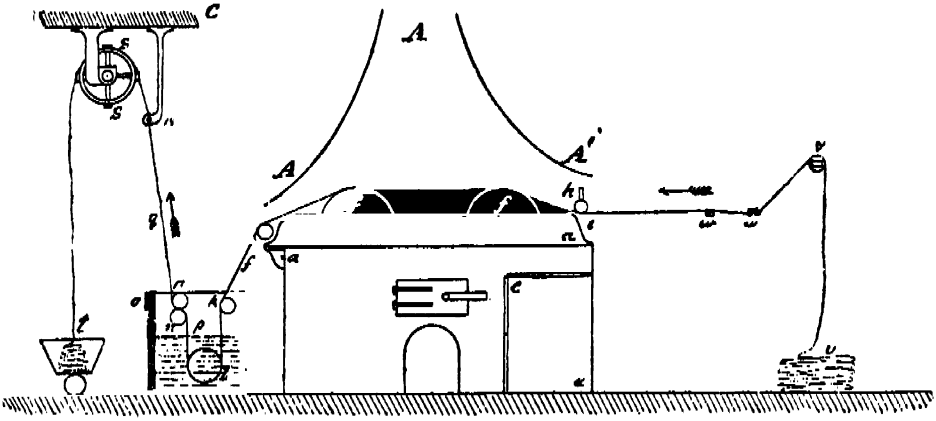


Fig. 1.

Second Process of Calico Preparation—Bleaching.

The grey calico having now been deprived of the loose cotton-ends, has yet to be freed from a variety of foreign matters, which would seriously interfere with the effect required to be produced in colours upon the cotton. The cotton is naturally of a dirty yellowish colour, and contains mineral matters and other impurities, besides what is contracted during spinning, etc., such as grease, dust, and other adhering mechanical impurities; and it is to be converted into a beautifully pure white calico, perfectly clean and free from all dirt and grease, before it is fit to be printed upon. This is effected by the process of bleaching, the first operation in which is "*steeping*," or letting the riband of pieces lie for some length of time in water, so as to thoroughly saturate them, as the cotton has a tendency to throw off water and keep dry, owing to the greasy and other matters which it contains. The cotton to be bleached, as it comes from the singeing operation, in the form of a long riband, sometimes measuring in its full length some thirty or forty miles, and composed of pieces sewn together, passes first through a ring, generally of porcelain, so as to bring it into a rope form, and passes into the steeping kier, hereafter described. This kier is filled up as evenly as possible, the rope being laid down regularly by a boy inside the kier, till nearly filled, when water is run in and the calico is left there for several hours. In many bleach-works steeping is omitted, the calico being wetted as it comes from singeing, as already mentioned.

Washing.

The goods are now thoroughly washed in a washing machine, to remove whatever in the cloth is soluble in water. There are many forms of washing machine, one of which is represented in fig. 2. In this washing machine the uprights A, A, support two wooden rollers, *b b* and *c c*, the former revolving on the shaft *e e*, by the pressure against it of roller *f f*, which is driven by a wheel *d*, connected with gearing. The calico enters the machine at A, passing through a ring *a*, and so being brought into the rope form, it passes between the two rollers *b b* and *c c*; the roller *b b* is a little further back than *c c*, so that, looking at the figure, the cloth passes at the back of *b b*, then between the two and down the front of *c c*. The riband thus falls into a box, *k k*, plentifully supplied with a good force of water. It falls to the bottom of the box, lies there a few seconds, and then ascends as at *r*, passes between the rollers, again descends as at *s* in the same manner, and so on repeatedly till it arrives at the opposite end of the machine and passes out at *h*. The various ascending ribands are prevented from becoming entangled by passing between parallel wooden rods, either as they leave the water box or immediately before passing between the rollers, as shown by vertical lines in the figure. The water enters the box at *k* and at *m*, where the washed calico leaves the machine, thus finally washing the cloth, while the overflow of dirty water takes place where the unwashed cloth enters the water at *n*.

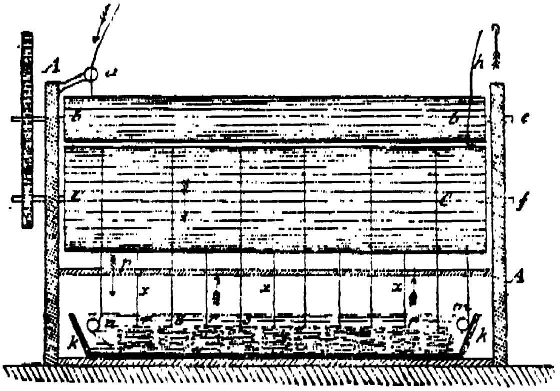


Fig. 2.

Liming, or Preliminary Treatment with Milk of Lime.

The "goods"—the calico being so technically termed—are run into a mixture of slaked lime and water, and kept rapidly running in it for some time. The mixture of lime and water, or milk of lime, is placed in the box of the washing machine, fig. 2, provided with several pairs of rollers for squeezing the cloth, in addition to the rollers shown in the figure; the cloth runs in this machine until thoroughly saturated with the milk of lime, and then passes at once into the liming kier. The exact quantity of lime used in liming is not of great importance, provided there is not a deficiency. About 10 to 15 lb. of lime to 200 lb. of cloth may be used.

Boiling with Lime.

The calico is next led into a large kier, the same as that used for steeping, and packed, as before, very closely and regularly. Fig. 3 is a section of a boiling kier: *a a a' a'* is an iron boiler, generally of cast iron for smaller sizes and for low-pressure kiers, and of wrought-iron riveted plates for larger kiers and for high-pressure kiers; *b b* is a false bottom, or grid, *a' a'* being the real bottom; *c* is a vertical pipe with an umbrella-shaped cover at the top, a short distance above the end of the pipe *c*, strongly secured to it by means of iron rods. The steam enters under the false bottom by the pipe *d d*; there is a steam-tap at *e*, and the steam-pipe *d d* is perforated. The run-off for the dirty water is shown at *e f*.

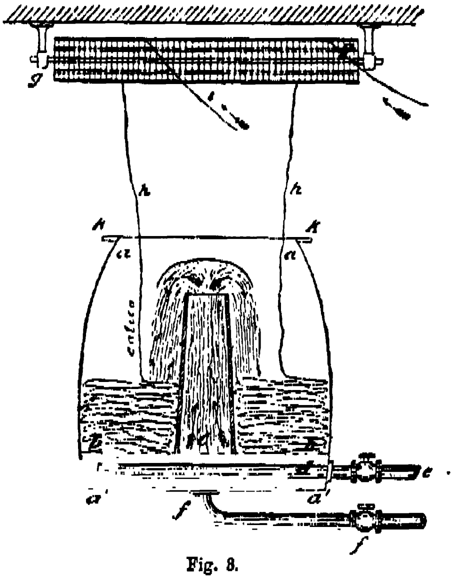


Fig. 3.

The ribands or ropes of cotton pass into the kier by means of the wince *g g*, the action of which will be evident on reference to the figure. The wince is supported from the roof. When the kier has been completely filled up and well packed, it is filled with milk of lime, the lid is put on and screwed down, and the steam tap at *e* opened, the tap *f* being, of course, closed. Fig. 4 represents the kier when working. The steam from the pipe *d d* causes a

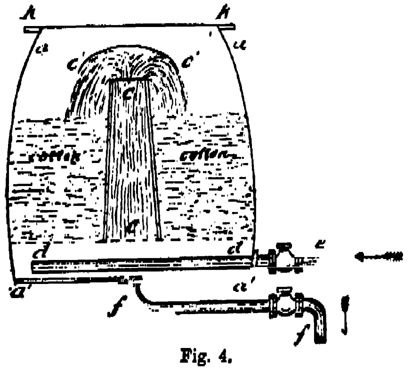


Fig. 4.

violent current of hot liquor to ascend the pipe *c c*, and is projected with great force against the umbrella cap *c′ c′*, which by its curved form dashes it through the pieces of cloth marked "cotton," and then through the grating or false bottom near *d d*, as shown by the dotted line, and is immediately again driven up the centre pipe. Thus a strong circulation of the liquid is kept up, and the pieces are thoroughly boiled. The length of time the pieces are boiled depends upon the nature of the cloth, and varies from eight to twenty hours or more. When the boiling is finished, the steam is turned off, the liquid run out at *f f*, and the kier filled up with fresh water. The cloth is now run through a washing machine, and receives a thorough washing, to remove lime and all matters rendered soluble or loosened by its action.

"Souring" after Lime.

This operation follows the washing, and consists in running the cloth through water rendered sour or acidulated with muriatic acid (hydrochloric acid or spirits of salt), or by vitriol (sulphuric acid). The calico passes through a machine similar to that used in liming, passing in and out of the "sours" five or six times, and is then squeezed and piled up in heaps in the bleach-works, and left to stand for three or four hours. After this the cloth is again thoroughly washed in a washing machine, to free it from all acid and matters dissolved by its action.

Boiling with Soda Ash and Rosin Soap, or "Bowking."

This is the next step towards the production of the pure white calico. The cloth is again tranferred to the boiling kier, and closely packed. A solution of soda ash and rosin, or rosin soap, is prepared by making a solution of soda ash in an iron kier or tub provided with a steam pipe, and adding gradually about half as much rosin as there is of soda ash. Several hours' boiling effects the solution of the ingredients.

When rosin soap is employed, the quantity of soda ash introduced into the kier is reduced by an amount equal to that contained in the soap taken. The liquid, as above prepared, is now run into the kier containing the calico, and when filled up the lid is screwed down and it is boiled in the usual manner for several hours—the exact time again depending upon the nature of the cloth, as well as the pressure of steam used in boiling. In some kiers low-pressure steam is used, but more recently high-pressure steam has been adopted. The latter is said to do the work much more quickly, but not quite so efficiently.

It is well to mention here that if the soda ash employed contains no caustic alkali—which, however, most qualities in the market do—it is necessary either to causticize a portion by the addition of some *lime*, or to add an equivalent quantity of caustic soda. When the cloth has been sufficiently "ashed," as it is termed, as above, the riband of pieces is passed through a washing machine and thoroughly washed; it is then subjected to

Treatment with Bleaching Powder, or "Chemicking."

At this stage of the bleaching process the cotton is free from its chief greasy and mineral impurities; but yet it exhibits a dirty or yellowish tinge, which must now be destroyed. This is effected by the action of free chlorine generated from bleaching powder and an acid—these two agents being applied to the cloth in two separate operations.

A clear solution of bleaching powder or chloride of lime is made by dissolving the powder in warm water and allowing the insoluble matters to settle down. The clear liquor is generally made of specific gravity 1·09 or 18° Tw., and added to the chemicking kier in the required quantity, which varies according to the quality of cloth to be treated; but generally chemic at 18° Tw. is reduced with water eighteen times for use in the kier. The calico is allowed to steep in the dilute chemic until thoroughly saturated; it is then run out to be "soured." The fabric is by this treatment little affected, the chlorine contained in the chloride of lime being not yet free—this being accomplished by the next process of "souring."

"Souring" after Chemic.

The goods saturated with dilute solution of bleaching liquor are passed either through dilute hydrochloric or through sulphuric acid, whereby chlorine is set free in the fibres of the calico, and all colouring-matters are destroyed or *bleached* by its action. The pieces are then finally washed in fresh water, and after smoothing out the riband of cloth, are dried over steam-heated cylinders, similar to those shown in fig. 5.

It must not be forgotten that in bleaching, no less than in many other operations of calico printing, the process varies in details in different works. We have given the general method, and that which clearly exhibits the principles of bleaching.

In the case of some kinds of cloth, and for certain classes of work, the operation of singeing is partially or wholly substituted by a mechanical process of removing the hair ends, etc., by running the cloth, drawn very tight, over a sharp knife-blade. This method is called "shearing."

In most cases the bleached calico is next submitted to a process of brushing, by means of a roller covered with a brushing of stiff hairs. The calico is rapidly run with pressure upon the roller, which revolves with great speed in the opposite direction. The object of this operation is to brush off loose hairs or cotton ends, and is performed immediately before the cloth is taken to the printing machine, being rolled on an axle as it leaves the shearing machine.

THE STONE MASON AS A TECHNICAL WORKER.

THE PRINCIPLES AND PRACTICE OF, AND THE MATERIALS HE EMPLOYS IN, HIS WORK.

CHAPTER I.

Introductory.

Of the early history of the art of Masonry nothing positive is known. There is but little to be met with on which what might be called reasonable conjecture can be based as to what constituted the earlier works of the mason. When we come to the period in the history of man's civilization in which regular structures of stone begin to appear, we find the details very much mixed up with the progress of the sister, or, as we should perhaps call it, the mother, art of Architecture.

In tracing the details of the work of the mason as a handicraftsman, we may succeed in tracing the steps by which what may be called the rough and ready-to-hand methods were, by careful observation of the effects of different methods at command, gradually brought to that position in which perfection has been attained in the art of working stones and its practice has become based on fixed and accepted principles. Those principles have thus raised it to the dignity of a science; so that from the art or handicraft skill in working stones and placing them in position in the structures in which they are used, we shall arrive at that point at which we have a science of masonry, properly so called.

Leading Divisions of the Subject.

It is our purpose to give to our readers a series of diagrams, drawings, and descriptions illustrative of masonry considered as both an art and a science. This naturally divides our subject into two parts. The first of them will take up the various kinds or classes of walls in the formation of which as a rule, with few exceptions, the work known as the mason's is employed; the kind of stones, or more properly the physical form, shape, or configuration in which the stones are used, and the methods by which these stones are built up into the wide variety of structures known as buildings in stone, or masonry. The second part concerns itself chiefly with what may be called the science of masonry, in which theory gives its aid to practice in affording rules and methods by which the various forms of stones required in the more complicated stone structures, such as arches, niches, vaults, etc., can be obtained with rigid accuracy. The forms or configurations of the stones composing these are more or less complicated or varied, but all require to be shaped and cut according to the positions they are to occupy in the structures for which they are designed. And this shape or form is dependent upon the employment of certain methods of what is called "projection," by which graphic representations are obtained to scale of the form required. In these methods the science of geometry plays an important part, and the labours of the draughtsman are necessitated for this department of the work of masonry. (See the series of papers entitled "The Building and Machine Draughtsman," the later sections of the present paper, and "The Geometrical Draughtsman.") Proceeding under this briefly expressed plan of arrangement of subjects, we take up first what may be called the handicraft part of masonry, inasmuch as its work chiefly depends upon the skill of those who have been brought or bred up to the mechanical working of stone.

Definition of the Term Masonry—The Distinction between it and Bricklaying.

Masonry has been defined—to follow the principle laid down by an eminent authority—as a bulk or mass of stone, either cut to regular shapes or forms, or taken as they are brought from the quarry or dug up from, or found on the surface of, the soil, of irregular shapes and sizes; those being either bonded, held together or connected by mortar or cement, or simply by resting on each other, or interlocking, so to say, more or less completely with each other, no mortar or cement being employed.

According to this authority, brick is a material which comes properly within the domain of masonry. In this country, however, the trade or business of bricklaying is distinct from that of the stone mason, each being, as a rule, carried on quite independently of the other. But the method of placing or superimposing bricks upon one another to form a wall or structure demanding a peculiar method of working, known technically as "bonding" (which term, so far as masonry is concerned, will be presently explained), and the employment of different, though less complicated appliances and apparatus—takes, as we think, the art of bricklaying within a category at least somewhat different from that of masonry. So that we deem it advisable to divide the two, giving a special paper or papers devoted to the bricklayer's work, just as we devote the series of chapters of which the present is one to the art and science of masonry. (See "The Bricklayer or Bricksetter.")

Other Materials used in Wall Construction.

There are, however, methods of constructing walls (see the "Cyclopædic Dictionary of Technical and Trade Terms," section Building Construction) which may be considered the typical forms of artificial structure, other than with stone or with brick. The materials employed in these other systems are first soil or clay worked up under the system of "*pisé*"; second, "concrete," which may be called a species of artificial stone. Of those two materials and methods, *pisé*—using soil or clay—is still occasionally employed, and is useful in colonies and remote districts where skilled labour to work up stones or make bricks and to build them is either very dear or cannot be had. Of the second, or concrete system, it may be said that from its use presenting so many advantages, it is being largely and still more successfully employed. There should be no reason why the carrying out of these two methods should be made to lie within the province of the mason any more than that they should be taken up by the bricklayer. In point of fact, both trades are quite competent to carry out both methods, and often in point of fact do so; although concrete building has lately received such an impetus that it has almost become a special trade or calling. But as both systems must receive some notice at our hands, we shall give what space can be spared to their description within the range of the present series of papers, this forming an integral part of it.

The Typical Form of Masonry the Wall—Its General Features.

All stone structures—and the same holds equally true of brick—or as they are popularly designated, "buildings," are spaces of ground enclosed by walls of greater or less length, height, and thickness—those three dimensions, which go to make up the solid wall, varying according to circumstances. There are a few exceptions to this rule, such as in the vast masses of great breadth and length employed in the construction of harbour, and in some classes of railway work, in the formation of floors of tanks, and the like; but these are nearly all but apparent exceptions, and might be safely classed as walls only of unusual dimensions or bulk or built upon unusual positions or sites. For the same method of construction is adopted; and even in the last-named exception, a floor may be in one sense said to be a wall, only posed or placed horizontally. All walls do not, however, enclose spaces. They often skirt or bound the side or end only of a space of ground, and are termed bounding or boundary walls; while others are built up against the face of a bank of earth, and are called retaining walls. The various forms they assume will be explained hereafter. Meanwhile we proceed to describe the methods by which they are built up, and the various forms which the materials employed assume. In one sense walls might be considered at first as divisible into two parts—first, the conditions or forms in which the stones forming them are met with in practice; and second, the way in which they are superimposed one upon another, held and tied together. This method will, in point of fact, be here and there adopted; but it so happens that the two are so intermixed with each other that it is difficult to separate the consideration of the stones themselves, and that of the way in which they are built up to form a wall. This, however, is observable in the early stages of the question, or in the simple forms of walls. We shall reach a point shortly in which we get the dual position of the two more distinctly marked, when we shall take up each separately.

The Simplest Forms of Walls.

Following the features of what may be called the natural system of building, by which the art of masonry arose, we take the simplest of all the methods of forming walls. In the earliest times the first walls, or attempts at erections like walls, would probably be made by taking such stones as could be found most ready to hand. Those would be found lying in the field, cropping up on its surface; or would be dug more or less easily from its soil; or they might be found in larger or smaller heaps and collections in the beds or channels of torrents and rivers. Such stones are generally more or less rounded, as at *a*, *b*, *c*, and *d*, in fig. 1, and this from the action of flowing or running water. This is the case even in the stones found on field surfaces or dug up from their soils. For it is to be remembered that those soils are for the most part deposits, laid by the action of water, or subsiding from them. Frequently also, when the rocks to which they belong are different from the soil in which they are found, having been brought from a distance by icebergs or glaciers, they have, when the ice has melted, been deposited *in situ*. To form walls of those stones with rounded surfaces would to the early builder be a matter of some difficulty, from their tendency to roll upon one another. This difficulty, which in course of time would with us be designated technically as their giving bad "bedding" stones—that is, stones which would not lie readily at rest when placed upon each other or in a heap—would be easiest got over by mixing up the stones with clay or soil somewhat in the fashion shown in fig. 2.

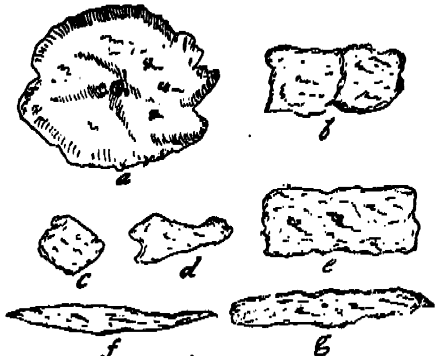


Fig. 1.

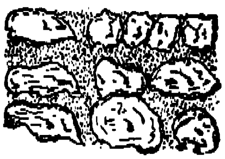


Fig. 2.

This method closely resembles what is known as "Kentish ragstone work," only that the stones used are not rounded, at least not large, as in fig. 2;

but are selected more on account of their comparative thinness and flatness; the former about the thickness of a brick, and somewhat of the shape as at *f*, or possibly at *g*, in fig. 1. When walls are constructed of the kind of stones such as *a*, *b*, *c*, *d*, in fig. 1, and connected together not with clay, but with strong sound mortar, poured in thinnish condition between them, a good strong, lasting, and economically constructed wall can be obtained. In many districts excellent specimens of this method of building exist, which may be classed as the simplest, as it was probably the earliest adopted.

Rubble Stones and Rubble Walls—Random Rubble.

When stones are not obtained of the kind or class described in two last paragraphs, but are got in what may be called the natural condition in which they are quarried, the walls formed of them are called "rubble." Rubble stones are of various forms and sizes: from the "splinters," such as at *f* in fig. 1, obtained from the dressing and squaring of the large blocks used in the higher class of work known as "ashlar," presently to be described, up to blocks of stone of more regular forms, as at *a*, *b*, *e*, and *g* in fig. 1. Splinters, however, or as they are often termed "shivers," are generally used for filling in the central parts of walls, on which practice we shall have yet more to give. Walls formed of "rubble" work are of two kinds. First, what is called "random rubble," which is simply putting the stones in place to form the desired thickness, and in such a way as to keep them perfectly vertical. These points are secured without any attempt to lay the stones in even or horizontal courses parallel to each other more or less; the result being very similar to that shown in the upper sketch in fig. 3; supposing the stones to be larger and not so round as those shown, somewhat like the arrangement shown in fig. 4 at *a a*. Rough as walls of this kind would be at first, when quarrying would be done in the roughest of ways and with the simplest of tools, in process of time, as the quarrymen succeeded in breaking up the rock into larger masses, those of the largest size would naturally be placed at the bottom of all, as at *b b* in fig. 4, so as to form a kind of bearing surface on the ground. This would especially be done in cases where the soil was softish and liable to yield to the pressure of the weight of wall above it.

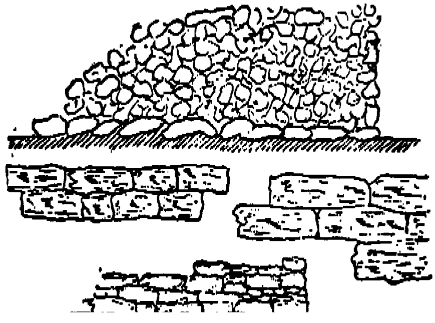


Fig. 3.

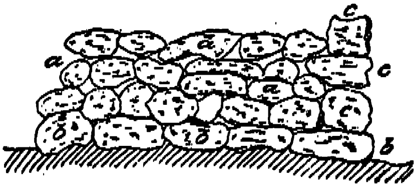


Fig. 4.

Broad Bearing Surfaces in Building Stones.

For the value of a broad bearing surface of stone would be quickly learned. The same might be done at the sides at *c c*, in fig. 4, or as shown in larger scale at the lower sketch in fig. 3. The sketch in fig. 9, p. 24, may be taken as illustrative of an early style of building a wall, in cases where an abundance of small-sized stones could be had, with only comparatively few large-sized ones. Those latter would be taken to enclose the small-sized ones—those too small to be placed upon each other or to bed upon one another. And if the whole were cemented together with good mortar, a very strong wall would be obtained. This would be an advance upon the method shown in fig. 2, where the mortar, clay, or binding material was largely used. This mode of construction was, indeed, frequently adopted, and such examples of it as have come down to our own time show how very lasting are structures built in this way. The knowledge of the value of bearing surfaces would soon lead to the choice of such stones as turned up in the quarry operations possessing flat sides, if not flat ends. Those would, for superior work, be preferred, not only on this account, but also as looking better or at least more uniform when the wall was completed.

Rubble Walls—"Coursed Rubble."

This would lead to the use of an advanced style of masonry work in wall construction. This is now known technically as "coursed rubble," and is constructed with stones which receive a partial dressing in or at the quarry, so as to give them faces more or less square, or with those selected with some care, of as uniform a size and shape as possible. The first elements of this coursed rubble work are shown in the central sketches in fig. 3; a partial combination of rough or random rubble being shown at the corner of the lower sketch of this central group in fig. 3.

Fig. 5 illustrates coursed rubble work in a wall in which the stones are of pretty equal thickness (as at *a a*) and length, so that a degree of external uniformity is obtained. This would not be always so, as stones of this character could not be always obtained in the great numbers frequently required. In this case the thinner stones, as at *b b* in the lower sketch, would be used in the upper part of the wall, superimposed upon the thicker and heavier, as *cc*, the best place for which would obviously be nearer the ground.

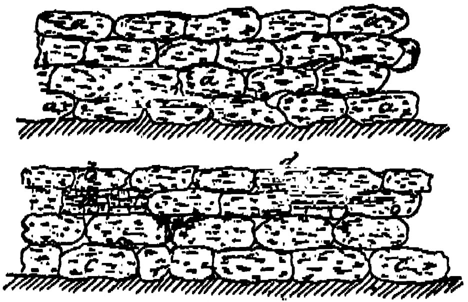


Fig. 5.

Very thin stones would be best used at places in the wall in the manner indicated at *dd*. Fig. 6 illustrates part of a wall in cross section—in coursed rubble work in which the system of using stones of various sizes is adopted; the thin and smaller-sized stones being of course placed in the interior of the wall, but still laid together in as uniform a manner as possible.

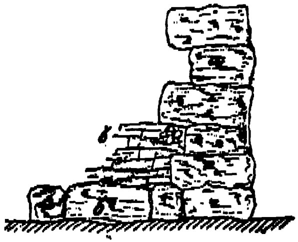


Fig. 6.

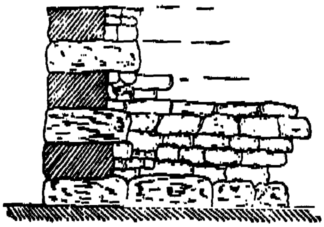


Fig. 7.

Fig. 7 illustrates also in cross section, giving the thickness of the walls, the combination of thick and thin, and also long and short stones; the inner thin stones, placed also on the coursed rubble system, being disposed or put in place as evenly as possible.

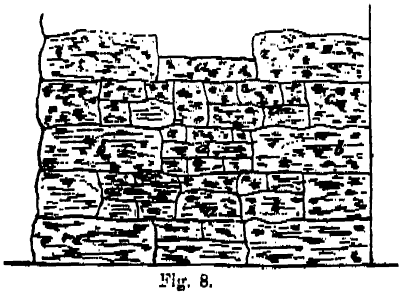


Fig. 8.

In fig. 8 another combination is shown, the outer foundation stones or lower courses being of uniform length and thickness; the outer face stones in the courses above being alternately long and short, as at *b* and *c* (shown also in fig. 7), while the inner and thin stones at *a* are made up in courses also. In fig. 9, small stones (as at *c c*) on the random or rough rubble system are used to fill in the central part of the wall, being thrown in at random and held or cemented together by thin mortar, termed "grouting," poured in amongst them.

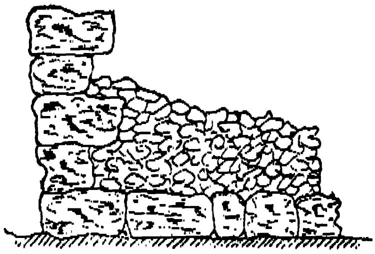


Fig. 9.

In this section of wall, also, long and short stones are used after the first or foundation course. As to the effect of this combination we shall have presently more to say, when we describe the method of obtaining greater strength in walls by the system known as "bond" or "bonding."

Ashlar Work.

Meanwhile we proceed to describe the next method of preparing and disposing stones, which is known as "ashlar." We have said that in coursed rubble work the stones are chosen as uniform in size and thickness as possible, just as they are quarried—that is, without being subjected to tool working. Although this is the rule, the stones for coursed rubble work are often partially dressed or tooled, so as to give faces as uniform as possible, as at *a a* in fig. 10.

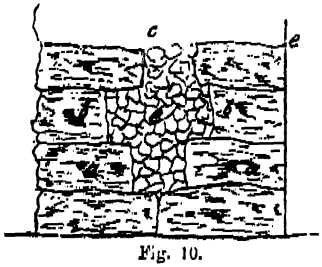


Fig. 10.

When the front face is tooled or dressed, so as to give a straight or even surface, and the top or bottom—that is the bedding surfaces—are left rough as they come from the quarry, the work when finished gives to the outer or exposed surface of the wall a smooth face. Coursed rubble work of this kind is called technically "snecked," and when the stones selected are pretty uniform in dimensions, affords the nearest approach to "ashlar" work, in which all the faces are at right angles to each other.

THE ORNAMENTAL DRAUGHTSMAN:

HIS STUDY AND THE DETAILS OF ITS PRACTICE, CHIEFLY IN RELATION TO TECHNICAL WORK IN MANUFACTURING DESIGN.

CHAPTER I.

Introductory.

IT is only of late years that the art of Ornamental Drawing has taken a place as one of the departments of technical work; or rather, as it may perhaps be the more accurate way to put it, as an indispensable adjunct to certain branches of the technical arts and manufactures, tending by its services to add that high value to their products which correct *design* is so well calculated to ensure. Nor need this be much matter of surprise, for it is in truth only of late years that what, for lack of a better term, is called technical work has occupied a well defined position, as one of the factors which go to make up the sum of those national industries which minister so markedly to the national wealth, and the comfort and the luxury of our people. The term "design" here used may be, and is in its fullest sense, applicable to all branches of industrial work, for where there is anything to be made, its making is obviously dependent upon design of some kind. And design in its strictest sense is, as its name indeed denotes, the product of mind as applied to the doing of any kind of work. To all the constructive arts design is absolutely essential, as in the making of a machine, the building of a house, or in the construction of its furniture. But the term "design" is in all those cases used here in its restricted—some may say its widest—sense. But it is restricted in so far as it really is applied to the purposes of construction only. The machine might be designed and constructed to work well; the house built so that one might live "comfortably" in it; the chairs might be made to sit upon, after some fashion, easy or uneasy as the case might be; the tables to sit at and eat from, or do designing work upon; and the beds might suffice to give sound sleep. And yet of each and of all it might be said that in no sense were they good for the artistic taste to dwell, nor pleasant for the artistic eye to look upon. In brief, a construction might serve its purpose and be in very truth well "designed," so far as that purpose was directly concerned; but might notwithstanding be as ugly as could well be. Or, to use the common expression, any one looking at the construction would almost intuitively or instinctively say, that it had "no beauty"—that it was not "beautiful." The term construction here used is applicable to an enormously wide variety of objects and things—to everything, indeed, "made" and fashioned by the patience, the skill, and the energy of man. Now, when we come to take up the canons or rules of art, we shall find that all—even authorities presumed or assumed to be, or in reality such—are by no means agreed as to the definition of the term "beauty," or in other words, what constitutes the "beautiful."

Design in its Technical Sense.

We here use the term "art" in its more restricted sense, as concerned only with objects directly produced by one or other of the branches of trades, manufactures, or businesses now flourishing amongst us; and as only in the remote sense connected with what may be called high or pure art—in which imagination or fancy gives birth to a conception which is recorded in what we call a painting, picture, or drawing,—whether it be an inanimate subject, as a landscape, or representative of some phase of life. In this restricted sense the term "design," receiving or having given to it a definite phrase or a technical term, may be, as it has been and often is, called Ornamented or Ornamental Construction. We shall see hereafter that there may be other terms by which the branch of technical study to which this and succeeding chapters under our general title will be devoted may be defined. For present purposes the name here given as definitive of what ornamental drawing is, or the duties of the ornamental draughtsman are, will be sufficiently clear and explicit, as conveying even to the popular mind a fair conception of them.

Ornament—Ornamental Construction.

For there are but few who, if they could not explain what they understand by the term "ornament," certainly can do so quite well enough for their own satisfaction. And although, like the terms "beauty" and "beautiful" above alluded to, those of "ornament" and "ornamental" are not definite and precise, but rather relative and conventional, so that different definitions will be given by different minds,—still there is with nearly all a point or points at which one object can be said to be ornamental, or at least to possess some claims to it, and another that it is not. Nearly every one knows pretty clearly what is meant to be conveyed by the word ornament; everywhere one hears the phrase, "that is no ornament"; and although no two would probably agree as to what true ornament is, they would have no disparity of opinion as to the truth or fallacy of the application of the term to any object. A tub, for example, or a barrel, few would pronounce to be an ornamental article; but another vessel—to hold an equal quantity of water or beer—could be made of such a form that it would at once be pronounced ornamental. And this although two, agreeing thus far, might never agree as to any standard which each might set up by which he judged of the relative purity of the ornamented or ornamental form of the newly "designed" vessel. Ample illustrations of these remarks will be found in succeeding chapters of the present subject; but enough has been given by way of introduction to it.

The Art of Ornamented or Ornamental Construction, or the Technical Department of Art Manufactures, of but Recent Introduction.

The art, as a branch of technical study, had no practical existence but a few years—comparatively—ago. It is difficult, if indeed it be really possible, to point out, not half a dozen, but three or four branches of arts and manufactures, in which there was, we do not say an honest attempt made, but a thoroughly practical and successful system in existence by which ornamental design was applied, two or three generations ago. The period at which the new and vastly improved state of things was begun dated from or about the opening of the Great Exhibition of 1851—a generation ago, or a little more. Then almost every branch of our arts and manufactures was simply waiting to obtain all the advantages which the ornamental draughtsman and designer was able to impart to it.

Sundry Considerations affecting the Work of the Ornamental Draughtsman.

Before proceeding to give our remarks on the principles of ornamental drawing, and the details of its practice, we deem it right to place before the student sundry considerations respecting the Art of Drawing in its widest sense. This to the superficial reader, who merely glances at the few pages which are to follow, may appear to be, on the contrary to this, but a very limited sense; being apparently applicable to the general artist, or as he is sometimes called the painter of the ordinary class of works of art termed pictures, whether those of landscape, historical, or figure subjects, or of both.

Essential Importance of Mastering the Elements of Ornamental Drawing.

It is a very trite and commonplace thing to say that there can be no sound building without a sure foundation. Still the lesson which this conveys is not seldom lost sight of in everyday work. And while the truth of that other saying, that it is best in any work to begin at the beginning, is not disputed by any one, still we fear that its lesson is also sometimes overlooked by those who begin the study of Ornamental Drawing. It is quite necessary that we should become thoroughly grounded in the first principles of this particular branch of the art, if we intend to develop our knowledge of it with any satisfaction to ourselves, or with any reasonable hope of ultimate success. The practice of "skimming" over the elements upon which alone true progress is based, is, we hope, unknown to the readers whom we are addressing. He who would attempt to study Euclid without first understanding the definitions, postulates and axioms—he who would design a bridge without taking the foundations into account—he who would become a chemist without an acquaintance with the bases of chemical combinations—is just the kind of man whom we should expect to hope to become an ornamental draughtsman with a contempt for the elements of design. Certainly not more senseless would such a man be, than the young ornamental draughtsman who refuses to do so much of downright beginning or elementary work as is necessary to enable him to draw lines and curves with equal facility and accuracy. We shall emphatically insist upon the general truth of this principle all the way through this paper—namely, that which costs one nothing is worth nothing, and that the value of a victory is to be estimated by its difficulty of accomplishment.

The Lines of every Form, whether in Nature or in Art, reducible to two.

Has it ever occurred to the young ornamental draughtsman that all the forms and combinations of forms, whether in nature or in art, are bounded or terminated by two kinds of lines *only*, one straight, the other curved? It is exactly with drawing as it is with every other art or science which can boast of anything like method or system, that there are certain great central principles which give birth to others; and those in their turn, being generative, produce what we may call principlets, and so on *ad infinitum*. One leading or certain leading principles lies or lie at the root of any science, and every principlet of the complete system springs either directly or through ascending steps of various degrees of removal from this or from those principles. So is it true that every form, in every department of drawing, whether figure, landscape, ornamental, architectural, or geometrical, however complicated that form may be, is reducible to the two classes of lines, straight and curved.

Ability to draw accurately the Two Classes of Lines essential to the Young Draughtsman.

But the great fact for the young ornamental draughtsman to consider as a truth is the one at which we hinted in our opening remarks—namely, that it is imperatively necessary that he be able to draw these lines with something like mathematical accuracy, and that he learn to do this at the very threshold or outset of his career as artist or draughtsman. To imitate with decision and firmness any object placed before him, or to "body forth the forms of things," to know the right kind of line to employ, and to be able to employ it, is quite essential. It is this fact which gives to such systems of drawing as the one which Kumpa of Dresden claims with charming simplicity to have been the first to introduce, their value and weighty significance. It is the importance of this which alone excuses and explains the dry drudgery to which most art students are subjected in the beginning of their study. It is this complete mastery of manipulative obstacles which we especially insist on; and we earnestly desire the student, through consideration for his own interests, not to advance one single step up the ladder until he finds his foot firmly placed on the one below.

The Materials employed in Ornamental Drawing—The "Tools" of the Draughtsman in his Earliest or Elementary Work—Different Materials and the Methods of using them explained—Slate and Pencil System.

It is here necessary that we should say a few words on the materials which it will be advisable to use in commencing operations, before we proceed to our more specific instructions. This is a point of much importance, and as it has created some difference of opinion, it may be well for us to present the notions of various authorities on the point, and afterwards state which we think best.

Herr Kumpa, of Dresden, to whom we have just referred, recommends the pupil to use, in his first attempts, either a slate and pencil or cheap cartridge paper and charcoal. The advantages of the slate-and-pencil plan are, that after the small first cost, the expense is practically nothing, and that mistakes are quickly and easily rectifiable. Two-pennyworth of slate-pencil, rightly used, will suffice—it is claimed for this system—to make a man a finished ornamental draughtsman, whilst the errors can be more rapidly erased than committed. One seeming disadvantage of this plan is, that the permanence of the drawing is entirely out of question. We have said disadvantage, but it is more than questionable whether this should not be included amongst the advantages. For the youthful ornamental draughtsman may rest assured, that for quite a long time to come he will not be able to draw anything *worth* keeping. His efforts will be weak, wavering, and wilful, and the permanence of things possessing such characteristics is an evil under the sun. Preserving first drawings, then, is by no means a very desirable proceeding; and it is one of the finest habits a man (whether artist or not) can get, to use an eraser, when necessary, without flinching. There is, however, always something, if not much, to be said on both sides of a question. And there is this advantage in keeping the efforts in drawing from the beginning,—that they afford, as it were, a record of results at various stages, and in this way admit of comparative observations being made as to progress. We know, as the saying is, of "no end" of cases where "copies" of all work are kept. Indeed, we may question if this be not the rule amongst the best masters of schools of art throughout the United Kingdom. But perhaps a real drawback to the use of a slate may be found in the fact that the transition from slate to paper is not of the easiest; and as in practical working, drawings will be on the latter material, it is decidedly better to become accustomed to use it as early as possible. One has, after all, to deal with paper ultimately, so one may as well get over any difficulty as to its use at the beginning — indeed, better, as time is in reality gained. For there is but little practical use in learning to use materials which are not, and indeed from their nature cannot be, employed in the after practice of ordinary work.

The Cheap Cartridge Paper and Charcoal Pencil or Crayon System for Elementary or Groundwork Lessons in Ornamental Drawing.

The charcoal-and-paper plan next claims attention. Mr. George Wallis and also Herr Kumpa are at one in recommending the student to adopt this method. Herr Kumpa tells us that "The student should be supplied with paper of a coarse description. The pencils should be charcoal, which has the double advantage of marking with a small pressure, and of being easily obliterated, by which the pupil is compelled to a light and free touch, and much paper will be saved." Mr. Wallis says, "I approve of the charcoal upon paper." We would, however, advise the beginner in ornamental drawing to be careful how he follows the course recommended by our Dresden authority—at least for the reason he gives. The use of charcoal, he affirms, will compel the draughtsman to a "light and free touch." Now, if one could make anything like a reasonable calculation of the miles of good drawing-paper which have been wasted by "light and free touches," it would make one pause before acting upon Kumpa's advice. The reader, who is here supposed to have some knowledge of the art of ornamental or freehand drawing, has most probably been requested at times to pass an opinion on the portfolio sketches and "finished" pictures of amateur artists. If his views of faithfulness in painting have in anywise coincided with those expressed by good authorities,—if he has come to regard it as an art, in the practice of which downright toil and immense experience are essentials to success,—if, in short, he has begun to estimate the value of a picture by its nobleness of conception, and the amount of earnest labour expended upon it, he will remember the pain with which he witnessed the mortification of his amateur friends when he has tacitly condemned their "light and free" compositions by abstaining from passing judgment upon them. Do not let us be misunderstood here. "Lightness" and "freedom" of touch, when they are the result of perfect mastery over the pencil,—a mastery which is only to be acquired by long continued and painfully concentrated effort,—

are admirable. Let an artist give the "lightness" and "freedom" of a Gainsborough every kind of praise, by all means; for of him Ruskin has said, "His stroke was as light as the sweep of a cloud, as swift as the flash of a sunbeam." But when these things are said to be characteristics of the drawing or painting of one whose experience is bounded, say by that of a couple of years, one may very safely, as a general rule, condemn them and the system of which they are the result. So that one may with some degree of prudence refuse to adopt a material which promises "lightness and freedom" of touch without that perfect mastery over the pencil above alluded to; and which, as a rule, can be got only by heavy struggle and years of difficulty. But perhaps, after all, Kumpa has been unintentionally overlooking the disadvantages arising from the use of charcoal. The fault lies partly in his erroneous statement; but, we are bound to say, partly likewise in the material he recommends. Its peculiar softness and friability may fit it for rough sketches of subjects which have to be worked up in another material; but for the student to begin using it at the outset of his attempts at line drawing is not only "too rash, too unadvised, too sudden," but it appears to us to be a pretty certain road to artistic weakness in work.

The Pen-and-Ink and Scrap-Paper System for Elementary Work of the Ornamental Draughtsman.

The plan which Mr. Ruskin recommends differs widely from the other two. He advises the student to supply himself with pen and ink and any old scraps of paper within his reach. In this advice may be traced, we think, the influence of some of Ruskin's noble principles of thought. "Let us have," we can fancy him saying, "the definite, the clear, the indubitable; give us truth direct and unmistakable; but in nowise, good friends, forget that man has a weird strange soul within him, which will grope, it may be blindly enough, but will grope, nevertheless, after the infinite. Remember this, in all things, courteous student. Choose pen and ink for clear blackness and clear whiteness. Choose them, likewise, for minuteness and mystery." Now, we have tried this plan of Ruskin's with something more of application than we have bestowed upon the two previously mentioned, and it needed but slight experience to convince us that it was immeasurably superior to either the slate or the charcoal and paper. It is surprising to some who give this method a fair trial for the first time to note how definiteness and delicacy are within the limits of the pen's capability. It possesses wondrous power of subtlety and mysterious refinement. The slightest shades of meaning, so to say, in lines, are within its power of expression, and in this most important respect the other two plans will not bear with it a moment's comparison. And the expense is next to nothing. We think very highly indeed of Mr. Ruskin's system, and commend it to the careful consideration of the student.

The Black-lead Pencil and Drawing Paper System for Beginners in Ornamental Drawing.

The good old-fashioned plan of black-lead pencil and paper we shall treat of lastly. These are the materials which we suppose some of our oldest readers, "whose heads are growing grey," used when learning to draw at school in their early days. One can recollect how the miserable trifles of well-thumbed "drawing copies"—the only ones obtainable by the pupil in those times when the "press" had done so little—were handed round without much reference to individual capacity or idiosyncrasies. With reference to this black-lead pencil plan, we may say that our opinion is favourable; but that in those characteristics which we have named as belonging to the pen, it fails to attain to the pen's excellence of flowing softness and distinctness. Now, the plan we would recommend the pupil to adopt in the study of ornamental drawing is that in the earlier stages of practice the black-lead pencil should be used, till some firmness and facility of execution or handling be attained. This, however, does not prevent the pupil from using the pen and ink afterwards, when greater subtlety and intricacy are required than are expressible by this material. He will, of course, accustom himself to the use of pen and ink, whilst at the same period of his practice he is also busy with making the curves and lines in black-lead. Let progress in the mastery of the two be carried on simultaneously—that is, if the two be used.

The Kind or Class of Materials the Student is to be provided with.

The pupil is supposed to have provided himself with an F or H B black-lead pencil—costing from one penny up to fourpence or sixpence, according to quality—a sheet of cartridge-paper, which may be had for twopence, and a small drawing-board, the cost of which need not be even a shilling, or at the most eighteenpence. The cartridge-paper is stretched on the board after the following fashion:—Damp the paper on both sides with a sponge dipped in quite clear water, and afterwards smear a little common glue, or strong dissolved gum arabic, along the edges, about half an inch in width. Lay the paper, after it is again surface-dry, on the board; and place it thereon exactly square, or as nearly so as possible, and then with a sponge press it gently down on the board. Let it lie, then, for say a couple of hours, when the paper will be found dry, stretched, and ready for use.

THE FACTORY OR MILL HAND AS A TECHNICAL WORKER.

THE ORGANIZATION, GENERAL DUTIES, AND SPECIAL WORK OF THE STAFF OF FACTORIES FOR THE PRODUCTION OF SPUN AND WOVEN GOODS—THAT IS, "YARN" AND "CLOTH"—AND THOSE CHIEFLY IN COTTON AND WOOL—GENERAL DESCRIPTION OF THE VARIOUS PROCESSES OF MANUFACTURE.

CHAPTER I.

Introduction—Wide Variety of Fabrics in which Cotton is Employed.

GREAT BRITAIN is, and has been, the seat of the cotton manufacture in all its branches, and it may be called the birthplace of textile goods in cotton—the first and by far the most important of her textile manufactures, and to which, therefore, we direct our first attention. The enormous population employed in the preparation and finishing of this material gives it the leading position in this country. Cotton yarn, in its entirety, is largely used in the form of calicoes, prints, fustians, velveteens, etc. It is also made use of in the worsted districts, as a material for mixture with worsted goods. When prepared for that purpose it is strong, and therefore used in the longitudinal parts of cloth—termed technically "the warp" (see a succeeding chapter on "Weaving")—in the weaving of goods such as are manufactured in the district of Bradford, in Yorkshire, mixed with goods—such as alpacas, merinos, cashmeres, coburgs, etc., etc. Cotton yarns for the "warp" are therefore in considerable request in the woollen manufacturing districts, being used mostly in what are denominated "common goods," and in fancy cloths, such as at present are fashionable, and have been for many years past. Cotton prepared for this purpose, being strong, bears a great pressure or tension in the weaving, which makes it so well adapted for such goods, and it has the further advantage of being produced at a low price. "Cotton waste" (*i.e.* the inferior part which is taken out of cotton, short and coarse, whilst it is undergoing the processes of carding and spinning) is very freely used in the districts where inferior manufactured materials in wool are made; and it is used along with the short wools in the first process or preparation, and is thus thoroughly intermixed. Cotton in the form of "warp twist," or yarn, is also employed largely in the Nottingham manufacture of laces, nets, etc., etc.; and in the same form it is also used largely in the silk manufactures. In the worsted, woollen, and silk manufacturing, the cotton thus used is hid by a process of weaving which throws up the worsted, wool or silk to the top (the face side).

Localities in which the Cotton Manufacture is carried on: Lancashire its Chief Seat.

It will thus be seen in what various forms cotton yarns are employed, and therefore it will be clearly understood why the cotton trade employs its millions and why it should stand in such a prominent position and take the lead of all other manufactured fibrous materials. We may say, if we take a district of twelve miles (all round Manchester), that in cotton spinning and manufacturing its trade will, in its value, exceed that of the whole world. Certainly, if we take the whole of Lancashire, we might safely make this assertion. This trade in cotton is really the staple business for Lancashire, for which may be said to exist all the other trades—such as bricksetters, joiners, engineers, millwrights, machinists, in all branches, and a score of others, to furnish the various materials—as, for instance, rope or twine makers, belt manufacturers, etc., oil and tallow merchants, cotton merchants, waste dealers, and sundry other dealers in the various materials as they are cast off, together with all such articles as are again worked up in the Lancashire district. All the worn-out or cast-off materials used in the cotton trade, as well as all cast-off articles in any other branch of trade, find a market readily; and the various matters in and about the works of cotton mills are not wasted when cast on one side, but are used for more inferior goods. Take, as an example, cotton waste, which is the inferior or refuse part got out of the raw cotton. When it is carded or spun (*i.e.* taken through all the ordinary processes of the raw cotton), being of a coarse, dirty nature, it is made into coarse yarn suitable for carpets, candle-wicks, etc., etc.; and is also, as we have said, not uncommonly mixed largely in with common articles of the wool manufactured goods. Some of the worn-out materials belonging to the cotton-spinning and manufacturing mills will be more minutely treated of as we proceed.

In a succeeding chapter we shall give a brief description of the numerous towns in Lancashire engaged in the cotton manufacture, with a statement of the peculiar classes of goods for which they are noted. And from this, in the mere extent of the list, the reader will be able to form some conception of the gigantic nature of the cotton trade carried on in the districts clustering round the great city of Manchester as a centre. And although he will further be helped to come to a more accurate notion respecting it when we tell him that the towns which make up the body of the cluster as a whole are in themselves large towns, many with some tens of thousands of inhabitants, this will still convey but a very inadequate idea of what the real state of the trade is. We have just said that these clustering towns are large; but they are very small compared with the vast city which forms their centre. This city, like a gigantic wheel, is year after year extending the length of its numerous arms, till they are touching town after town, the locality of which but a few years ago was deemed by the inhabitants to be such as placed them in such a relation to the great "town" that they could well claim that separate corporate existence which seems now in danger of being absorbed by their mightier neighbour. Nor does all we have stated exhaust the field of the cotton trade. Although its real centre is Manchester, Lancashire does not monopolise the whole of it. Here and there—as at Derby as a centre, and as far north as Carlisle—cotton factories not a few, taking them in their aggregate, are to be met with in other counties of England: even London, the characteristics of which are somewhat if not essentially different from those of the manufacturing towns of Lancashire, can boast of at least one pure cotton factory. But we must leave England and go much farther north than even Carlisle before we can exhaust the localities in which the cotton trade flourishes and forms an important factor in the general sum of national prosperity. In Scotland we find that busy seat of trade and commerce, Glasgow—beyond doubt the second city of the empire in population and in wealth—contributing largely by the number of its factories to the general aggregate of those of Great Britain, taken as a kingdom.

We shall now take up the various departments of the work done in a factory for the spinning of the yarns used in the weaving of cotton cloths, or as they are very generally termed, calicoes; pointing out the nature of this work, and detailing the duties of those hands who attend to it. Previous to this, however, it will be well to give a few remarks on the material itself.

The Material from which Calicoes are Made.

Cotton is a vegetable downy substance found in the seed-pod of a tree called a "cotton-tree." This is very extensively planted in America, Egypt, and India; and although we receive small quantities from China and other parts of the world, the above countries are those we so largely depend on for our supplies of the article. The pods of a cotton-tree may be likened to the buds of a rose-bush. When they begin to open, like the rose-bud, then the pickers, women and children trained in this branch of work, go through the plantations, and pluck the cotton and seeds of those that are ripe, leaving the husks behind. The cotton as it is gathered is full of moisture, and therefore requires drying. The cotton with the seeds thus gathered are exposed to the sun until they are quite dry. As they are gathered after being dried they are operated upon by a machine called a "gin." This "gin" causes the seeds to be separated from the fibres of the cotton. We must say that all the seeds are not taken out of the fibres of the cotton, but only comparatively so. This "machine-ginning" is the only operation through which the cotton has to pass before that of packing it into bales. When they arrive in this country they are known by every schoolboy as bales of cotton. The cotton from America and Egypt is enclosed in coarse wrappering, and is so closely packed by machinery and with the aid of a little water occasionally put in the bales while being packed, that though small in bulk it sometimes reaches the great weight of seven hundredweight, or nearly 800 lb. Like all other articles which are imported into this country from distant parts, it is sent very often by sailing ships, the carriage by such ships being less than that by steamers, and articles of this kind not being of the importance of some goods, which would deteriorate seriously by a long voyage. London is not reckoned generally as a cotton port, though we have had cotton many times which has been bought in that market. Liverpool is the true market for cotton of all growths. The cotton broker knows the district where it has been grown by the name which is given to it. For instance, Brazil cottons are distinguished by the names of Maranham, Pernambuco, Para, etc. Cotton brokers not only know readily the places where the different varieties are produced, but they can describe the quality very accurately; just as we often speak of West of England woollen cloth, that district having the reputation of producing the best cloth made in England.

Qualities of Cotton used for Different Classes of Goods.

Indian and American cottons are principally bought to make the general class of calicoes or coarse goods, for whatever purpose it is employed in. The Egyptian cotton varies very much in its quality, but is nevertheless used in some cases with and for the same purpose as that from America. A low class of yarn, say "40^s," is made from the coarse quality, and all intermediate counts of yarn are spun from that number (40^s) up to 150^s. In addition to the fine yarn, as it is termed—150^s being made from the finer qualities entirely—we would say, and that from experience, that 200^s yarn is spun from a mixture of fine Egyptian cotton with others of a still finer quality. The next fine, nay, we may say the finest, cotton used is that commonly called "Sea Island." All the very best and the finest goods are made from the "Bourbon" and "Sea Island."

THE MACHINE MAKER OR GENERAL MACHINIST.

SPECIAL EXAMPLES OF HIS WORK—ITS LEADING TECHNICAL PRINCIPLES AND DETAILS.

CHAPTER I.

Introduction.

SOME one has made the remark that our country owes its wealth and power to its machinery. Like all sayings of the kind, which limit the creation of a certain position to one influence only, overlooking all other influences; this, while in its nature exaggerated and paradoxical, contains nevertheless much that is absolutely true. For if one more or less closely examine the varied powers which have ministered in times past, and minister now even more decidedly than of old, to the wealth and position of our country, one is constrained to confess that machinery possesses not the least influential of positions. For the more closely we look into what may be called the inner life of even those branches of commerce which seem at first sight to have but little connection with machinery, we find that in reality they are dependent upon it,—that without its help their business would be at a standstill. And so far as trades generally are concerned, it is difficult to find one, which in one way or another is not largely dependent upon what machinery does for the details of its work. But if we turn to special branches of trade, we find that they are wholly dependent upon machinery, which in reality constitutes the only power by which they exist and by which the wealth of the country is so enormously increased. We need only refer to the textile manufactures in proof of this, or what are more widely and popularly known as the cotton, the wool, the silk, and the flax "trades."

Manual Labour the Characteristic of the Early Periods of Manufacturing Industry.

At one period in the history of our country such limited work as was done in the making of the fabrics which constituted either the necessary or the luxurious clothing of the people was done almost wholly by manual labour. But even in those, the days of primitive simplicity of work, machinery, or at least simple forms of mechanism, were used. Without them, indeed, but little progress would have been made, notwithstanding the dexterity of the hands and the accuracy of the eyes that formed such striking features in all trades, which then were much more accurately defined as, or termed, manufactures (see the "Cyclopædic Dictionary of Technical Terms" for the derivation of this word) than they are now, when the hand does so little and machinery so much. The very term, indeed, indicates that the work of our textile trades was almost wholly dependent upon the manual skill of the workmen and workwomen employed in them. And it is curious, as it is suggestive, to observe as indicative of the high position which the textile trades occupied in popular estimation as the power which ministered so much to the well-being of the community, that the term manufactures was applied almost exclusively to the products of our textile trades, and the term "manufacturer," as indicating a calling or trade pursuit, was applied only, as it is still understood to be, to those who were engaged in their production. Nor need surprise be expressed at this; for in those early days, as now, next to the supply of food, that of clothing occupied the highest position in the estimation, and demanded the highest skill of man.

In glancing at the influence which machinery has exerted in creating the wealth which has in turn given the power that has placed us at the head of all nations of the earth, we are more than justified in referring to our textile trades as the most striking example of what that machinery has done for us. We have said that for long the work of those trades was done almost wholly by hand, the mechanical helps which the "hands" possessed being of such a simple character that they were more worthy of the name of appliances than of machines. And it is curious again to observe here that the remembrance of this condition or state of matters is perpetuated in the term "hands," which to this day is usual to denote the workpeople employed in our cotton (and other cloth or textile fabric) mills and factories. And although the term has now got an extended application, being used to denote the workers in other establishments, it is still understood to apply specially to those of our textile trades.

Machine Working gradually Introduced as a Substitute for Manual Labour in Manufacturing Industry.

But as our population and our wealth multiplied, and as the spirit of commercial or trade enterprise, which is the special characteristic of the Anglo-Saxon race, increased and was extended in ever-widening circles, the simple mechanical appliances sufficed no longer to meet the growing demand for the textile fabrics which constituted the clothing of our own people and those of other countries who were but too eager to avail themselves of such scanty supplies as we could then spare from our own stock. Inventors, with some insight into, others with a remarkable prescience of, what the trade might be and could be made by greater helps to production, bent their minds to increase this by the aid of machinery. Simple as the appliances were, enough was known of their power in giving a production, which without them would have been altogether inadequate to meet the demand for the necessary clothing of our own people. So that there was every reason why men of an inventive turn of mind should apply themselves to find out mechanical helps to work which, from their superior arrangement and design, would be entitled more clearly to be classed as machines than the simple appliances which they were intended to supersede. In process of time, machine after machine was invented, made, and applied practically to the textile trades, till now we find that the minimum amount of manual labour is required to produce our textile fabrics, as compared with the period when machinery had comparatively no existence. But complete as the revolution has been which has substituted the work of untiring mechanism for that of manual labour, which at the best can give out only a limited power, the desire on the part of our manufacturers to still further do away with the necessity to employ manual labour is such that the chief work of our machinists may be said to consist wholly in the invention and manufacture of labour-saving contrivances and machines.

Circumstances which made the Introduction of Machinery into Manufacturing Industry a Work extending over a Long Period.

But while almost every one is acquainted with the fact that our great textile trades are now carried on by the aid of machinery almost alone used, workpeople or "hands" being employed chiefly to look after its working, it is only those who know the inner secrets or history of the trades who are aware how long it was before machinery *could* be applied practically to do the work of the men and women who at one period did it all, or nearly all. It was not that inventive genius was not forthcoming to devise machines more or less elaborate to perform the work before or then being done by hand, more or less intricate in its character. On the contrary, machines were invented at a period so early that they may with all truth be said to have been designed before they could be *made* so as to do the work practically. This may appear a strange statement to some, and to many its meaning will not be at all understood. The position may be thus simply stated. The machines invented by the real founders of the modern textile trades, such as Paul, Hargreaves, Compton and Arkwright, being designed to supersede manual labour, the mechanical movements which had to copy the dexterous and deft movements of skilful fingers, aided by sharp, intelligent eyes, were necessarily of a more or less complicated character. And being so, they demanded for their practical embodiment in machines which would work, the exercise of high constructive and mechanical skill on the part of the machine makers who had to construct them. They on their part had manipulative dexterity enough,—and, indeed, it may be said that a far higher degree of merely manual skill existed generally then than exists now amongst mechanics. Nor need this be matter of surprise, seeing that it was the mere dexterity of the hand and the accuracy of the eye to which they had to trust. Now-a-days the great majority of the operations of a machine-shop are done with precision and accuracy by machinery, all of which had to be gone through in former days wholly by the hand. And the reason is not far to seek. The mechanics at the time we have referred to, when ingenious invention after invention succeeded each other with astounding rapidity, possessed few tools; and of what may be called machine tools they possessed, say, but two—namely, the lathe and the boring brace—and these in arrangement and construction were of the simplest and the rudest.

The Early Work of Machinists—Tool Making and Machine Tools by which Machines are made—Material of which the Early Machines were constructed.

What machinists had to do at the period to which we are referring was not so much to increase their constructive or manual dexterity as to devise and to make tools by which they could render that dexterity more widely available in the construction of the machines which the textile manufacturers and inventors of textile machines presented to them, and so urgently required of them. It was not, however, so much in the way of devising and making "hand tools" to meet the demand for a far higher class of machinery than they had ever before, as a body, been called upon to make. For this machinery, not merely in the multiplicity of the parts, but in their delicate adjustment, necessary to meet the requirements demanded where the dexterous and nimble movements of the human hand guided and controlled by the human intelligence had to be imitated by machines alone, necessitated the employment of new materials in its construction. Up to the period of which we write, nearly all machinery was constructed of timber; at least, timber played the most important part in its make. This is easily accounted for. We have said that hand tools were few; machine tools could scarcely be said to exist, with the exception of the two rude and largely inefficient ones we have already named. And the tools, such as they were, were almost wholly fitted for the working of timber. The case assumed a totally different aspect when iron and the other metals, as steel and brass, began to be used. And their use was, indeed, imperative.

THE YOUNG ARCHITECT OR ENGINEER.

His Studies—Office Duties—and Practical Work in the Preparation of Working Drawings, of Specifications, and Contracts for Work.

CHAPTER I.

Introductory.

Under this title we propose to lay before our readers an account of the studies, practical, theoretical and historical, which the student must master to enable him to practise as an architect or as an engineer. The paper is intended specially for two classes of readers. First, those fresh from school or college who desire to join one of these professions, and who probably possess only very vague ideas of the arduous and anxious duties they will be called upon to perform, and of the prolonged and varied study to which many years must be devoted. The second class comprises those who have already entered the office of an architect or engineer; and who are anxious to take the fullest advantage of such opportunities as will there be placed within their reach, and to supplement them by careful and well-designed study at home. Some of the first class may probably feel that they do not possess the necessary ability and perseverance, and may by the perusal of our papers be thus saved both disappointment and loss of time. For details of the various subjects mentioned, the reader is referred to special articles under titles such as—"The Building and Machine Draughtsman," "The Domestic House Planner," etc. Technical terms, whenever used, will in the first instance be carefully explained; and as it is of course absolutely impossible for the professional man to do without them, the student is advised to commit them to memory. This will be greatly facilitated by frequent intercourse with other students, and by daily visits to buildings and engineering works whilst they are still in the contractors' hands.

Arrangement or Division of the Subject.

It might at first be supposed that the subject of office work and study would be all the better discussed under two heads, one applicable to Architecture and the other to Engineering. While certain advantages would flow from such an arrangement, still, as so large a part of what may be called the "office life" or the "articled term" is made up of work and duties *common* to both architects and engineers, while of so much of what is home study the same may be said—by treating them together we shall at least obtain the great advantage of economy of space, consequent upon a concentration which avoids a repetition of pretty much the same thing, which would be necessary in each paper if the professions of architecture and engineering were discussed separately. And the whole will be so treated that those comparatively limited points referring specially to one as distinct from the other will have that distinct place afforded them which will not cause any confusion between the two.

Distinction between the Work and Duties of the Architect and those of the Engineer.

It is in the first instance, therefore, necessary to point out wherein the architect differs from the engineer, what works are designed and erected by the one and what by the other. Briefly stated, all works in which construction is subordinate to design are architectural, and those in which design is subordinate to construction are engineering works. Every architect must be proficient in construction as applied to buildings; but design and proportion are the features of his work by which his merit as an architect is judged. To the engineer construction is paramount, design and proportion being only required in exceptional cases; and as the young engineer is rarely encouraged to cultivate an ability to design or to train the eye to a true appreciation of proportion, most attempts at design on the part of engineers are, from an architect's point of view, crude and faulty.

Classes of Work or Buildings which the Architect Designs, and the Erection of which he is called upon to Superintend.

The buildings which the architect may be called upon to design may be arranged into five groups. 1st. Places of public worship (church-work); from the dawn of civilization to the present time, amongst all nations and in all countries, the greatest architectural talent and skill have been called forth by and devoted to their erection. 2nd. Buildings of every variety and size intended for the habitation of man (domestic work); these form undoubtedly the most important group, and should be studied with special care, as every architect is probably called on to design buildings of this description in the course of his professional career, and any shortcomings must cause the utmost discomfort and probably loss of health to all those whose misfortune it is to inhabit houses badly planned and constructed (see a special paper on this important department, "The Domestic House Planner"). 3rd. Public buildings for utilitarian purposes, such as schools, hospitals, workhouses, asylums, and prisons; the preparation of plans for buildings of this group requires special knowledge, and experience on the part of the architect, who must not only be acquainted with all the legal enactments referring to them—which in some cases, notably lunatic asylums, are very stringent — but must also be familiar with their internal economy, system of management, classification, etc. 4th. Warehouses, factories, markets, banks, and buildings of every description intended for commercial and manufacturing purposes; this group is of comparatively recent origin, and has become in large towns and seaports of the utmost importance; ironwork is a special feature in their construction, and one that the student of architecture must study both theoretically and practically. 5th. Miscellaneous group; this includes government and municipal buildings, museums, theatres, monuments, etc. It is scarcely possible for the student to become thoroughly conversant with the requirements and details of each of the five groups; he is advised to select one of them and to devote the greater portion of his time and energy to its study, and to obtain a more general knowledge of the others, which, of course, cannot be completely ignored.

Classes of Work or Structures the Engineer Designs, and the Execution or Erection of which he Directs and Superintends.

The term "Engineer" is a very comprehensive one; the profession is divided into a number of distinct groups. The student must select one, and devote the whole of his attention to it. 1st. Civil Engineering, which includes railway, mining, dock and harbour works, water works and supply, sanitary and sewage works, the erection of roofs, bridges, etc., formation of roads, and a great variety of miscellaneous work involving masonry and iron construction. This group is so extensive, and includes such a variety of work, that civil engineers generally devote the whole of their attention to what may be called one sub-group, such as railway work or mining. 2nd. Telegraph Engineering. This has become a most important group within the last few years. It of course includes the laying of deep sea cables, to which a special article will be devoted. A practical as well as a theoretical knowledge of electricity and its applications is absolutely necessary. 3rd. Gas Engineering. This is a comparatively limited but distinct group. 4th. Mechanical Engineering. This, like civil engineering, may be subdivided into a large number of sub-groups, such as locomotive and engine work, spinning and weaving machinery, hydraulic machinery, etc. 5th. Military Engineering. This, like the third group, is a comparatively limited one, but, unlike most of the others, has a history extending far back to remote ages.

The System of Study of the Young Architect and Engineer.

Assuming that the student has made his selection, a brief account of the system of study in vogue in this country will now be necessary. It differs from that on the Continent, where there are technical schools for students of architecture and engineering, at which a number of years must be devoted to theoretical study before the practical work of the office is commenced. In this country, on the other hand, the beginner fresh from school or college is thrust into an office, in the majority of cases without any preliminary theoretical training, and allowed to pick up knowledge as best he may. There are, of course, exceptions to this objectionable system. London has its King's College, Crystal Palace School of Engineering, and the recently established Technical Institute, of which the large establishment at South Kensington may be considered the central college, as well as numerous classes for the student of architecture. In several large towns there are also opportunities of obtaining theoretical knowledge—in the Technical Institutes established recently, as in Manchester, Bradford, and elsewhere; but those who take advantage of them are in the minority, and will probably continue to be so until a compulsory examination is introduced which every student must pass before he can be allowed to practise as an architect or an engineer. We earnestly advise the student, if he has the opportunity, to devote not less than two years to preliminary theoretical study before commencing work at the office, which should extend over at least four years. When this is impossible—which will necessarily be often the case until technical schools exist in every large town—the student should supplement the work of the office by private study during his leisure hours. Advantage should in every case be taken of the schools of art, more especially by the young architect, to perfect himself in freehand figure drawing and perspective (see "The Ornamental Draughtsman," and the paper on "Form and Colour in Industrial Decoration"); water-colour painting should also be studied. The extensive, highly interesting, and instructive literature of architecture and engineering should be carefully read, and every opportunity taken of forming a small and well-selected library of professional books. The still more extensive range of Continental technical literature should not be overlooked. To this special allusion has been made in our opening paper, "Technical Education in relation to the Present Condition of our National Industrial Work," to which we refer the reader. The young engineer must devote a portion of his time to the study of mathematics.

We may conclude these preliminary remarks by suggesting that it is not desirable that the student should be immediately articled. A few weeks spent in the office before this is done will not be time wasted, as it will enable him to familiarise himself with the use of the drawing board, to gain some insight into the routine work of the office, and a last opportunity will be offered him of reconsidering the intention of becoming an architect or an engineer. If all the preliminaries have been satisfactorily arranged, the articles duly prepared and signed, the serious work of the student's career will commence. Routine office work and the studies in which proficiency must be attained by students of both professions will now be described. As already stated, detailed information upon all these will be found in special articles, to which the student is referred.

General Routine of the Office Work of an Architect.

The newly articled pupil must not expect to take an active part in the business of the office for some time; two or three months will elapse before he has familiarised himself with the daily routine work, even if he has spent a considerable length of time at a technical school and school of art, as he will find a wide difference between the real work of the office and that to which he has been accustomed. Of course his progress will be more rapid with than without the preliminary training. As every architect must be an expert draughtsman, the first duty of the beginner will be to acquire a knowledge of mechanical drawing and facility in the use of the drawing instruments, T-square and set-squares. These subjects will be described in detail in separate chapters, under the heading "The Building and Machine Draughtsman." Particulars of the principles and practice of freehand drawing, so essential to the architect and builder, will be found in the paper entitled "The Ornamental Draughtsman." This knowledge is generally acquired in this country by the persistent copying of office drawings: the beginner is thus enabled, whilst learning the rudiments of mechanical drawing, to familiarise himself with the work he will be expected to undertake later on. It is, of course, necessary to understand what the drawings copied represent; this can only be done gradually. Whilst engaged on this description of work knowledge will also be acquired (1) of the various processes through which each drawing must pass before it is considered complete; (2) of the variety of drawings required for each building or engineering work, from the first rough sketches to the full-sized details; (3) of the large amount of work required in each case, in addition to the drawings—such as the preparation of the specification quantities and contract.

General Routine of Outdoor or Field Work.

When some experience of indoor office work has been acquired, outdoor or field work will be commenced. This includes levelling and surveying, measuring up builders' work, setting out buildings, superintending their erection, etc. At the end of eighteen months, or two years, the pupil may reasonably hope to have obtained a fair knowledge of both indoor and outdoor work, and ought to have become a proficient draughtsman. Original work will then be expected from him, and his progress ought to be rapid; but it will depend entirely on his own ability and industry.

Drawing—The Primary Work of the Office -Processes or Steps through which Drawings must go to be Complete for Practical Use—Pencilling and Inking-in.

Each drawing goes through at least four processes before it can be considered complete: it is in the first instance drawn out in pencil, and is kept in this incomplete state until all the others belonging to the same "set" have been prepared, so that any alterations or additions may be made with as little trouble as possible. Beginners are too apt to ignore this rule, only to find when too late that much of their work has to be erased and re-drawn, which can scarcely be done without injuring the surface of the paper and permanently damaging the drawing. The whole "set" is then inked-in, and thus rendered permanent—a very tedious, though necessary process, as the drawings must be referred to daily for a considerable length of time, and if left in pencil would soon become indistinct and useless. The inking-in must take place in the following order:—First, all circular work that has to be turned in with the compasses must be done; it frequently happens, as in the case of a richly moulded arch, that the centre is completely worn away, and no hold can be obtained for the instrument—a small horn "centre" must then be used. After the circular work, all the horizontal, and then all the vertical lines must be inked-in; last of all the outlines and sections of mouldings, the carving, figures, and all other freehand work. When this process has been completed, the whole drawing should be sponged over; this is not an invariable practice, but it is strongly recommended; care must be taken that the water and the sponge should be perfectly clean; when left to dry the drawing must be placed in a horizontal position, so that this may take place uniformly over the whole surface.

The Colouring of Office Drawings.

The next process is that of colouring: the various materials indicated on the drawing, as well as the section and elevation portions, must be distinguished by different tints; each office has its own system of colouring, which is rigidly adhered to; one is given below which will be found useful. The colours should be applied as far as possible pure, so as to facilitate the matching of a tint if the supply runs short.

Decide what is to be coloured before commencing, and never leave a wash unfinished; if the area to be coloured is extensive, care must be taken to prevent the edges from drying; if compelled to leave whilst colouring, finish if possible up to a line, so as to hide the joint or edge. The application of a tint is frequently facilitated by mixing a slight quantity of ox-gall with the colour. Whilst being coloured the drawing should be slightly tilted. All the brushes, colours and palettes should be kept scrupulously clean. Always commence with the light tints; when a large number of drawings have to be coloured together, each tint should be applied in turn to the whole set. When it is desired to give a colour "body," Chinese white should be added. It is useful to know that crimson lake and other vegetable colours can be removed by means of dilute chloride of lime; after applying it (by *means of a special brush), it* must be removed with *water and blotting paper.*

Colours used in Office Drawings to indicate Different Materials in Elevations and Sections.

EARTHWORK.—Dark sepia, generally finished with a *jagged edge.*

CONCRETE.—*Light Payne's grey, dotted with dark Payne's grey or ink.*

DRAINS.—*Thick dark Prussian* blue lines.

BRICKWORK.—*Elevation: A light mixture of crimson* lake and Venetian or *light red; a distinction is generally made between stock bricks and common bricks,—the former are generally coloured darker; for blue* brick apply a second tint of Payne's grey. *Section:* The same as for elevation, but darker—sometimes scored with diagonal lines in crimson lake.

STONEWORK.—*Elevation:* Light wash of yellow ochre or burnt umber; flagging, light wash of Prussian blue. *Section:* Dark Prussian blue dotted with Indian ink, or scored with dark Prussian blue; flagging, dark Prussian blue.

WOODWORK.—*Elevation:* Ordinary joiners' work, light burnt sienna; baywood, same mixed with crimson lake; oak, same mixed with burnt umber; carpenters' work and all unwrought timber, light raw sienna. *Section:* Same as for elevation, but darker; generally scored diagonally in addition.

PLASTERERS' WORK.—*Elevation:* Light Payne's grey. *Section:* Dark Payne's grey.

IRONWORK (WROUGHT).—*Elevation:* Light Prussian blue. *Section:* Dark Prussian blue.

IRONWORK (CAST).—*Elevation:* Light neutral tint. *Section:* Dark neutral tint.

PLUMBERS' WORK (GLASS).—*Elevation:* Neutral tint, British ink or Prussian blue. *Section:* Same dark.

PLUMBERS' WORK (LEAD).—*Elevation:* Light indigo. *Section:* Dark indigo.

SLATERS' WORK.—*Elevation:* Neutral tint or indigo slightly mixed with crimson lake. *Section:* Same darker.

FOR SURVEYS.—*Roads:* Footways light Payne's grey, roadways light burnt sienna. *Water:* Light Prussian blue with dark border of same. *Grass:* Prussian green. *Sand:* Indian yellow dotted with crimson lake. *Earthwork:* Dark sepia applied with a dry brush.

Dimension and section lines: Crimson lake.

Hot water supply pipes red, cold water supply pipes blue, gas pipes indigo and crimson lake mixed; electric bell wires yellow; speaking tubes green.

Large sections are only tinted in outline.

The "Figuring" of Office Drawings, or Indicating the "Dimensions" of Various Parts.

When the colouring has been completed the drawings must be figured and written to; this constitutes the last of the four processes. The figuring of a set of drawings is very responsible work, and must be done with the utmost care, as even a slight error will cause great trouble and expense, and may frequently render large quantities of work, such as cast iron and joiners' work, useless; *it cannot be done too much in* detail, and should, *if possible, be so arranged as to check itself; this may be easily effected by means of* two parallel sets of dimensions variously subdividing a *given total length or height.* Two series of dimensions are required, vertical and horizontal; the former should be worked *from a fixed point or datum line,—* in the case of a building this may be a street level or some permanent feature in an adjoining building; the latter should be arranged, where possible, from centre lines or from a permanent base line.

The "Writing" or Titling of Office Drawings.

No drawing is considered complete until the following information has been placed on it, either in ornamental or plain black lettering, occasionally in ordinary writing. If the drawing is one of a set it must be numbered thus: "Drawing No. 5": this is generally placed in the right-hand top corner. A general title, uniform for the whole set, must be conspicuously printed in large letters in the top left-hand corner or in the centre, thus: "Proposed New Warehouse for Messrs. A. B. & Co., Victoria Street, London." The scale to which the drawing has been prepared must be dated or drawn. Every part of the drawing must then be distinctly described, thus: "Plan of Ground-floor," "Dining-room," "Drawing-room," "Land belonging to ——— Esq." Any information required to make the drawing perfectly clear should be given in a side-note. A plain border-line will complete the drawing.

Great Variety of Drawings required for Building and Engineering Works generally.

The variety of drawings that have to be prepared for every building and engineering work is very great: in most cases preliminary sketches, surveys of site, contract drawings, half-inch or inch details, and full-size details, are required. Perspective drawings or sketches, though very useful and desirable, are frequently omitted.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER I.

Introductory.

WHILE many branches of what has been called our national industry are possessed of numerous points of great technical interest, and present no inconsiderable claims to the attention of the social and political economist from the means of livelihood they afford to a large number of people, they cannot nevertheless be said to be of primary importance. And this inasmuch as many of them are concerned chiefly with the production of objects which, if they do not purely minister to luxury, at the best and highest add to comfort or pleasure, but in such a modified way as regards positive utility that they could be dispensed with, without materially interfering either with health or what constitutes true comfort, either personal or household. They cannot be said to be necessary to man's existence, and have only appeared at stages of his civilization where habits of luxury, or the fresh and ever forcible demands of fashion demanded supplies of new objects and contrivances. The case is widely different with those branches of natural industry which concern themselves with the supply of food, clothing and shelter. Those embrace all the arts and industries essential to man's existence, without the products of which he could not have obtained the physical advantages of what we call comfort, and without a sufficiently abundant supply at all times to be depended upon, have made any marked advances in an improved and ever-improving civilization. Hence it is that to those essential arts and industries the closest attention has been paid, and it is in connection with them that the highest exercise of man's ingenuity has been displayed, and his most untiring energy given to secure their fullest development. And of all the wide and varied branches of those three great divisions under which the primary wants of man are embraced, and which they have given birth to, those connected with the *food* of man have taken the first rank in the estimation of nations who have entered upon and have made progress in civilization. And of these, as of obvious necessity, the work of the farmer has taken the precedence. For the leading technical points of this we have to refer the reader to the series of papers entitled "The Farmer as a Technical Worker."

Increased and Increasing National Importance of the Work of the Grazier.—General Statement of the Mode of Treating the Subject of his Labours in the Present Series of Papers.

In the proper place, while treating of the practical points connected with the food required for the purposes of grazing, we shall have occasion to point out what are the circumstances in practical farming which have given such a marked prominence of late to the question of cattle farming as contrasted with cereal farming or corn growing. We shall then detail briefly how far the actual circumstances of farming—or of land—are likely to minister to the success or otherwise of the new system so much advocated, and which may be expressed in the now well-known phrase "Grass land against corn-growing land," and how far this is realised, or controlled and modified by the actual condition of our soils. Meanwhile we at once proceed to name some points connected with our mode of treating the general subject.

From one point of view this forms an essential part, and should be considered within the range of, the chapters of the paper entitled "The Farmer." One of the most important departments of the technical work of the farmer is, in truth, that which concerns itself with the breeding, the rearing, and the fattening of live stock, or, to use the more popular and more generally understood phrase, the domestic animals of the farm. Strictly considered, the phrase "live stock" includes horses, but it more frequently is understood to mean those animals which are bred, reared and fattened for the express purpose of being killed to provide animal food for our teeming population, these animals being cattle, sheep, and pigs. In this view, horses and dairy-cows come under another category—although, after serving as producer of milk from which butter and cheese are made, the dairy-cow is usually set aside and fattened and killed, or if in good condition killed off at once to serve as food, in the same way as oxen or cattle are killed. Another source of food is poultry. This, however, in the usual economy of British farming, does not form part of its work, the British farmer somehow looking upon poultry keeping, as this department is called, as a work altogether beneath the dignity of his calling. What is done, therefore, in the way of providing for the wants of our population in the matter of eggs and poultry for the table, so far as we ourselves as producers are concerned, is left almost wholly to the chance work of those who farm in a very small way, and to the large number of cottagers, and those resident in or near the neighbourhood of large towns, who take more to poultry keeping as a fancy or hobby, than as a means of livelihood, or the increasing of their income. The farmer, as a general rule, keeps but a small flock of poultry, to which he pays no attention, leaving them to be looked after by the female part of his household, or if neglected by them, leaving them to look after themselves. As a rule, our people are supplied from the Continent with the great majority of the vast number of eggs they consume; poultry keeping being there considered as an art, to which great attention is paid, even by many farmers who farm on a large scale. And this inasmuch as, with really greater practical business prudence than is possessed by farmers here in this connection, they see that poultry keeping is a large source of income, and can, if properly attended to, be made to pay as well as any other department of live stock. Although at present a prejudice exists in the minds of British farmers against the keeping of poultry, we are of those who believe that as juster and more accurate views obtain as to what really are the general principles regulating the supply of food for our increased and ever increasing population, this department will take that place in the regular work of many farms which the merely pecuniary interests connected with it demand and justify, but which place is not now accorded to it. Whether this is likely to be the case or not—and its truth will assuredly be disputed by many—it is, to put the matter in a somewhat practical way, worth some degree of national effort, to produce ourselves by one plan or another those large supplies of eggs and poultry for which at present we are compelled to go abroad, and as a consequence send there large amounts of money to pay for them. We believe that one of the benefits which will ultimately spring from the adverse circumstances under which British farming has of late years been placed will be a strong conviction in the minds of those engaged in it as a technical calling, that its pecuniary interests will best be served by taking advantage of *every source of income* connected more or less directly with the land. And in this acting on the truth of the general principle, that each department will pay, but however can only pay when the closest attention, and the most advanced practice is given to it. It is in vain to expect good results when care is not given to work. There is no sound reason why we should send yearly out of the country large sums of money to purchase articles of food which we can, if we choose, produce ourselves, and we venture to say produce as well and with as large a profit if only we pay attention to it. Beyond all question, our farmers have lost sources of income simply through lack of care in keeping them, or through prejudices against them as vague as they are unfortunately potent in the way of practical evil.

We shall consider, therefore, the work of the grazier under this important section in its most extended sense, as a provider of animal food for the people. It will thus in our pages be connected with the three classes of farm live stock—namely, first, "Meat Produce," including in this, as its chief sources, cattle or fattening oxen, sheep, and pigs; second, "Dairy Produce," including the care of dairy-cows and, as a practical offshoot, the making of butter and cheese; and third and last, "Poultry Produce," including the care of fowls, ducks, geese and turkeys.

Some Considerations bearing on the Business of Grazing as generally defined in our Title; as Different from that of Ordinary Farming or General Husbandry.

Looking, then, at this important department of farm work from the above point of view, it would seem at first sight that its details fall to be considered wholly within the range of the papers specially devoted to the work of the farmer. The great number of the details which come under the departments of farming, other than that of live stock, makes of necessity the series of papers specially devoted to them a very long one. But apart from this fact, there is this very practical point to be looked at, and which makes the severance of the work of the grazier and cattle breeder from that of the farmer purely as such, something more than a matter of convenience as dividing the general subject into two great heads—each of which will have a distinct place of its own within the scope of our pages—makes it, in fact, a very natural and a practical division or classification. The point here alluded to is this. In the earlier stages of the practice of farming—and not to go too far back, we may confine those to a period in our national history not much over, if indeed quite up to a hundred years ago—the farmer included within the range of his work every department. He not only cultivated the different crops then within his reach; he had grass lands for meadows, and fields for pasture; he bred, reared and fed live stock for the butcher, as fattening cattle, sheep and pigs, or was a grazier. He bred and reared his own horses, and his dairy-cows, and the produce of the latter he made into butter and cheese, or sold the milk, and was thus a dairyman; and if he did not take up the breeding and rearing of poultry for the table and for egg production, he always bred and kept more than enough for his own wants, so that as a rule he supplied his neighbours. And all this at a period in our history when transport of materials from a distance was both so difficult and so dear that the supplies from foreign sources upon which we now chiefly depend were not at the command of the people. This style of farming is still practised, and is now known as "mixed husbandry," but it is practised only to a limited extent, and is entirely controlled by circumstances of soil, climate, and locality; for it is not every place where the system can be carried out. But as our population increased, and with it the wealth which increasing prosperity brought with it, the demand for all kinds of farm produce increased also.

A DICTIONARY
OF
THE LEADING TECHNICAL AND TRADE TERMS
OF
ARCHITECTURAL DESIGN AND BUILDING CONSTRUCTION,

BEING PRACTICAL DESCRIPTIONS, WITH TECHNICAL DETAILS, OF THE DIFFERENT
DEPARTMENTS CONNECTED WITH THE VARIOUS SUBJECTS;
WITH DERIVATIONS OF AND FRENCH AND GERMAN EQUIVALENTS
FOR THE VARIOUS TERMS.

ABBREVIATIONS EMPLOYED THROUGHOUT THE DICTIONARY.—*Der.* for "Derivation," or the Linguistic Root of the Term; *Fr.* for "French"; *Ger.* for "German"; *Lat.* for "Latin"; *Gr.* for "Greek"; *O. E.* for "Old English or Anglo-Saxon"; *Eng. Pron.* for "English Pronunciation"; *Syn.* for "Synonyms," or Equivalents in French or German, or in both; *Pron.* "Approximative Pronunciation."

A

Abacus, *in Architecture.* The final or uppermost member of the capital of a column in one of the orders of architecture, on which in Classical architecture the Entablature (which see) rests, or in Gothic architecture from which the Arches (which see) spring. In Classical architecture, or what are called the Five Orders of architecture, the abacus is, in the Doric and Tuscan, a flat stone or tile, square in outline, with edges either plain or ornamented with mouldings. In the Ionic, Corinthian, and Composite Orders the abacus is square, but with each side hollowed out to a circular curve, and the corners cut off or truncated. In Gothic architecture the major portion of the capital being made up of foliage or ornament, the abacus is the only part which admits of mouldings being displayed. The form or outline generally determines the Gothic style or date of the capital. In the Norman it is square or plain, with the lower part chamfered (which see). In the Early English it is chiefly circular in plan; in the Decorated style it is either square, set diagonally, or circular, often octagonal. In the Perpendicular style the abacus is sometimes circular, but most frequently octagonal in plan. Eng. pron. abbey-kuss or ah-bay-kuss. Syn. Fr. *Abaque*, or *Tailloir*—pron. ah-baack, tah-ee-oh-ear or -eer—literally "a trencher" or "plate," and this from *tailler*—pron. tah-ee-eh—to cut, carve, or dress; Ger. *Abacus* or *Capital-platte*, or *Platte einer Säule*—pron. ah-back-us, kap-ee-tal-plattay or -plattch, plattch iner sow-lay.

Abattoir. A separate or detached building set apart for the slaughtering of animals designed to serve as butchers' meat, with special conveniences and appliances. Eng. pron. same as the French; vulgarly various, as ah-bat-ore or ah-batt-war. Syn. Fr. *Abattoir*—pron. ah-bah-twar or -tuah. *Der.* From the French verb *battre*, to strike or beat down, and this from the Latin *batuo*, I strike or beat down; Ger. *das Schlachthaus*—pron. shlaght-house—the ch or gh with the guttural sound (see Dissertation), hau pron. as between our word house and the Ger. *Haus*; from *schlachten*, to slaughter.

Abrevoir, *in Masonry.* The junction or juncture of the faces of two stones, the interstice between which is to be filled with mortar.

Abutment, *in Masonry.* The walls or piers at each side of an arched opening from which the arch springs and is supported, or upon which the ends of the arch abut. Syn. Fr. *Arc boutant*, or *Arc boutant culée* or *buttée*, or *Aboutissement*—pron. ark-boo-tangt (ng pron. nasally), kue-lay, buh-tay—ah-bu-tease-mangh. *Arc boutant* means the ending of an arch—from *bout*, the end. *Culée* means a stern-way, also an abutment—from *culer*, to go astern (koo-lay). *Buttée* means abutment. Syn. Ger. *der Brockenkopf*, or *Anstoss*, or *Strebepfeiler*—pron. brocken-kopf, ann-stoss, stray-beh-filer. *Brockenkopf*, from *Brocken*, a fragment, and *Kopf*, the head, *i.e.* the head-piece. *Anstoss* has a curious derivation—from *anstossen* (ann-stoss-sin), to push on or against, to stumble on—that is, the *Anstoss* is the stone which the entablature above it pushes against. *Strebepfeiler* is from *Strebe* (stray-bay), a prop, a stay, a buttress, and this from *streben* (stray-benn), to struggle against or contend with. *Pfeiler* is a pillar or pier, and this from *pfeilern* (file-airn), to provide or furnish with piers or pillars. Another German synonym for abutment is *Kämpfer*—pron. kemp-ferr—which has a curious derivation, like *Anstoss* above named. The word means a fighter or combatant—from *Kampf* (kamff), a struggle, a combat—*i.e.* the stone which fights against the weight or pressure of the entablature, its resisting piece. Another German synonym is *Widerlager*—pron. vee-derr-lag-err—from *wider*, against or in opposition to, and *Lager*, a bed, a couch, and this from *lagern* (lah-gairn or -gern—g hard), to lay down, to found. *Der.* The verb abut, to terminate, border, or meet, is from the French *aboutir*, to border on, to end, and this from *à*, at, and *bout*, the end or extremity of an object.

Abutting Joint, *in Carpentry.* The junction of two pieces of wood or members of an assemblage of timbers or framing. In this joint the fibres are, or the length of the one piece is, perpendicular to the face of the joint, and of the other member parallel to the joint. (See paper in text entitled "The Carpenter" for illustrations.)

Acanthus, *in Architecture.* A plant the leaves of which treated in a conventional manner form the distinguishing feature of the capital of the Corinthian and Composite Orders in Classical architecture. The acanthus is the basis of a wide variety of ornamental forms used in the decoration of objects in art manufactures. (See papers in the text entitled "The Ornamental Draughtsman," and "Form and Colour in Industrial Decoration.") Syn. Fr. *Acanthe*—pron. ah-kanth; Ger. *Bärenklau*, which is the German equivalent of the English name of the acanthus plant—Bear's Breech, or "the breech of the bear"—pron. bar-en-klow (from *Bär*, a bear, and *Klau*, a claw or clutch. The plant is also known as the Brank Ursine.

Accouplement, *in Carpentry.* A brace or strut in a truss or tie-beam. The term is purely French, and means a coupling—pron. ah-coople-mang. The English pronunciation should be the same, but it is generally given as ah-koopel-ment. The term *Accoupled* (Eng. pron. ah-koopeld) has for its French synonym *Géminé* (pron. ghay-me-nay), which has a curious derivation, as the word means iterated or repeated, and this from *gemeaux* (jhay-moh), and Lat. *gemini*, the twins, that is, for example, two coupled or twin beams. The same idea is conveyed in the German synonym, which is *Zwillingspaarig* (from *Zwilling*, twins or two, and *Paar*, a pair. The root of the term Accouplement is the verb *accoupler* (ah-koop-lay), to tie together, to pair or to couple.

Acroteria, *in Architecture.* Small pedestals for busts or statues placed in pediments at the apex or point of meeting of the angular sides, or at the corners or lower part of the pediment. Syn. Fr. *Acrotères*—pron. ah-kro-tares; Ger. *Giebelzinnen*—pron. gee-bel-tzin-nen. *Der. Giebel*, a gable, triangular wall or pediment, and *Zinne* (zin-nay), a pinnacle.

Adhesion, *in Building Construction.* Means the result of joining two separate pieces of material of the same or different character by means of a third material, as a cement, a glue, or a mortar. It also includes the connection maintained by a body, as a pin or nail driven into timber. The principle of adhesion is of special value to the joiner and cabinet maker in gluing the pieces of their work together. It lies also at the base of all work in which cements and mortars are used in masonry, and pins and nails in carpentry. Some idea of the adhesive strength of an iron nail driven into wood may be had, when we state that one driven into dry oak to the depth of two inches will require a force of half a ton to pull it out. The adhesion of nails to wood is much influenced by the relation the nail has to the fibres of the wood. If a nail driven into elm requires a force of 260 lb. to pull it out when driven endways—that is, parallel to the fibres—it will require a force of 830 lb. to pull it out if driven sideways or at right angles to the fibres. If two pieces of wood are well glued together with ordinary glue, the adhesive force, being reckoned at 700 lb. to the square inch, is often much greater than the cohesive force of the wood itself, taken at 560 lb., so that the wood may give way at its solid part before it gives way at the joint. *Der.* From the Latin word *adhæreo*, and this from *ad*, to, and *hærere*, to stick—to stick to. Syn. Fr. *Adhésion*—pron. add-haze-ee-ong (from *adhérer* [add-herr-eh], to adhere); Ger. *Anhaften*—pron. ann-haff-tane, to stick to (from *anhaften*, to grapple with, to clasp).

Adjust, *in Construction.* To place one piece in relation to another, so that when secured together they will lie in proper position. When two flat surfaces are to be adjusted they must be made perfectly true and "just"—as the technical term is, which is simply an abbreviation of the word adjust—so that no rocking or riding movement can take place between the pieces, but the pressure will be equally distributed over the whole of the surfaces. The technical term "justifying" work is the act of making the pieces true and "just." *Der.* From the Latin *ad*, to, and *justus*, right, true, correct. Syn. Fr. *Ajuster*—pron. ah-jooze-tay, to adjust or fit together (*ajustage*—pron. ah-jooze-tajgh, is the act of adjusting); Ger. *Berichten*—pron. bay-reegh (guttural sound) -ten (*Richt* [reeght], right), to make right or correct.

Adze, *in Carpentry.* A tool bent or curved in face, with sharp cutting edge, fixed at right angles to the handle and at its lower extremity, so that the edge is towards the workman, who moves backward as the operation proceeds. It is used for roughing off or rendering partially flat and smooth the surfaces of logs or bulks or large timbers. Syn. Fr. *Herminette*—pron. herr-me-nett; Ger. *die Krummhaue*—pron. dee croom-how-eh (*krumm*, crooked, bent or curved, from the verb *krümmen* [crem-en], to bend, and *Haue*, a hoe, a mattock, from *hauen*, [how-enn or -ane], to hew, to cut, to chop or chip, as an adze does).

Agreement, *or Contract.* A document containing the terms of an arrangement or bargain relative to the purchase of land for the site of a building, preliminary to the regular Deeds, or as to work of any kind to be done. *Der.* From the French verb *agréer*—pron. ah-gree-eh, to be in accord, of one mind, and this from *gré*—pron. gray, will, liking, accord; hence the phrase *bon gré, mal gré*, equivalent to our phrase "will ye, nill ye," *i.e.* whether you will or like it or no. Syn. Fr. *Convention* or *Pacte*—pron. kong- or kon-vahn-see-ong, pakt; Ger. *Vertrag*—pron. fare-trahg, and derived from *tragen*, to carry, to bear.

Aiguille, *in Architecture.* A French term sometimes used in place of its English synonym Pinnacle (which see for derivation). This term is used chiefly in relation to Gothic architecture, and denotes the pointed termination to certain parts, as buttresses. They are in the Decorated style specially beautiful as regards the ornamentation. For examples see the supplementary sheets of THE TECHNICAL JOURNAL in the Architecture and Building series. The term Aiguille is simply the French word *aiguille*, a needle—pron. ah-gweel.

Aisle, *in Architecture.* The side divisions or bays of a church, as distinguished from the body, nave, or central part. The term is derived from the French word *aile*, a wing—pron. ah-il, or somewhat like our word isle, which is nearly the English pronunciation of the word aisle. Syn. Fr. *le Bas-coté*—pron. bah-cot-tay (from *bas*, low, and *coté*, a side); also the word *Aile* as above; Ger. *Seitenschiff*—pron. zite-enn-sheeff—from *Seite* (zite-eh), a side or flank, and *Schiff*, a nave (also a ship).

Alcove, *in Architecture.* A recessed part in a building or room, or in garden buildings. In Continental countries, where the alcove forms part of a room as affording a recess for a bed or couch, it is separated from the main apartment by pillars or pilasters, termed an *Estrade*—pron. eh-strahd. Syn. Fr. *Alcove*—pron. all-kove; Ger. *Alkoven*—pron. all-kove-en.

Alto Relievo, *in Sculptured Work in Architecture*, or *Art Decoration.* Figures cut or carved so high as to appear very nearly detached from the surface or base. Eng. pron. all-too ray-leev-oh. When the relief or projection is just half the depth or height of figure, the term used is *Messo-relievo*, meaning middle relief—pron. med-dzo-ray-leev-oh. When it is less than half its full projection, the relief is termed *Basso-relievo*, meaning low relief—pron. bas-soh-ray-leev-oh. Syn. Fr. *Rondebosse*—pron. rongd-boss—from *ronde*, round, *bosse*, a knob, a lump; Ger. *Hochrelief*—pron. hogh (the guttural sound of ch) -ray-leaf (*hoch*, high).

Angels, *in Architecture.* Brackets or Corbels (which see) finished with the heads and necks of angels. They are chiefly used in Gothic or Pointed architecture.

Angle Bar, *in Carpentry.* The window bar at the corner of a projecting window. (See "The Joiner" in text.)

Angle Float, *in Plastering.* A tool termed a "float" (which see), made to suit the inside angle formed by the meeting of the two sides of a room, to work the surface of the plastering.

Angle Iron, *in Iron Work for Roofs, Bridges, etc.* Bars of wrought iron rolled so as to have their two sides at right angles to each other, thus: L. (See "The Iron Worker in Roofs and Bridges" in the text.) Syn. Fr. *Fer à cornière*—pron. fair ah korn-ee-air (*fer*, iron, *cornière*, a gutter or corner plate—from *cornier* [korn-ee-eh], a corner); Ger. *Winkeleisen*—pron. vin-kel-ize-en (from *Winkel*, corner, angle, and *Eisen* [ize-enn], iron).

Angle Rafter, *in Carpentry.* Otherwise termed a "hip rafter," being the rafters placed at the corners of a building which is covered with a hipped roof or truss, of which the ends have the same inclination or angle of slope as the sides. (See the chapter on roofs in "The Carpenter" in text.)

Annulet, *in Architecture.* A narrow moulding, square or flat on face, used to separate other mouldings. The narrow and flat or squared face moulding, or part separating the flutings or hollowed-out parts in columns or pillars, or in pilasters, are also called annulets. The word is directly derived from the Latin *annulus*, a ring. Syn. Fr. *Annelet*—pron. ann-lay; *annelet*, a little ring, from *anneler* (ann-lay), to curl or twist round; Ger. *Ringelchen*—pron. ringel-chen, a ringlet—from *ringeln*, to curl or bend round, to ring.

Antæ, *in Architecture.* Flat pillars, otherwise termed "pilasters," projecting from a wall. Syn. Fr. *Antes*, or *Pilastres*—pron. an-taes, pee-lasstz; Ger. *Anten*—pron. an-tane or -tenn.

Ante-chamber, *in Architecture.* In domestic architecture usually termed an ante-room—a small room attached to, or connected with, a larger apartment, entered either before or from the large room, as the ante-room of a drawing-room. Syn. Fr. *Antichambre*—pron. aunt-eh- or aunty-shawm-berr; Ger. *das Vorzimmer* (*vor*, before, *Zimmer*, chamber)—pron. fore-tzeem-err; also *das Eintrittzimmer* (*Eintritt*, entry, entrance)—pron. ine-trit-zim-err.

Antiseptic, *in Materials.* A substance generally liquid, or used as a paint, employed to preserve timber, etc. *Der.* From two Greek words—*anti*, against, and *septikos*, decay or putridity. Eng. pron. anty-sepp (*not* skepp, vulg.) -tick. Syn. Fr. *Agent anti-putride* or *-septique*—pron. ajz- or awj-aug antee-puuh-treed or -sepp-teeck, an anti-putrid or antiseptic agent.; Ger. *Fäulnisswidrig*—pron. foil-niss-vee-dreeg—from *Faulniss*, rottenness, *widrig*, repugnant or adverse to—literally "a substance opposing putridity."

Apart, *in Construction.* A term used to denote the distance between two pieces, as two beams or walls, and is equivalent to the expression "the distance or length in the clear or inside dimensions." Syn. Fr. *Dans* (within), *Œuvre* (work)—pron. dangs-oov or dang-zoove-uh, or dangz-oovh-er; Ger. *Innerlich* (internal) *im* (contr. for *in dem*, in the), *Gebäude* (building or edifice)—pron. in-err-leegh im geh-boy-deh.

Apartment *in Basement, Cellar, or Underground.* In some parts called the "cellar kitchen." Syn. Fr. *Tellier*—pron. tell-ee-eh; Ger. *Unterirdisches Gemach* (from *unter*, under, *irdisch*, earthly, and *Gemach*, a room or chamber)—pron. oon-tare-eer-dee-shess gay-magh.

Apartment, *in Domestic Architecture.* A room or chamber in the house, as distinguishing one room from another—literally "a place set apart." Syn. Fr. *Appartement*—pron. ah-part-mang; also *Chambre*—pron. shawm-ber; also *Pièce*—pron. pee-ace; Ger. *das Zimmer*—pron. tzim-err; also *die Stube*—pron. stoo-beh; also *die Kammer* (a chamber)—pron. kahm-merr.

Aperture of a Door, *in Architecture.* Otherwise called a door void, or opening. The space left in the wall of a house in which the door-frame is fitted. Syn. Fr. *Jour de porte* (from *jour*, a day, figuratively "a hole showing daylight," and *porte*, a door or gateway)—pron. joohr, or zhoor-deh-pohrt; Ger. *die Thüröffnung* (*Thür*, a door, *Oeffnung*, opening)—pron. tuh-eff-noong.

Aperture of a Window, *otherwise called a Window Void, or Opening.* The opening left in a wall into which the casement or window-frame is to be fitted. Syn. Fr. *Bail* (bay) *de croisée* (casement)—pron. bahl-deh krwah-say; Ger. *die Fenster* (window) *Oeffnung* (opening)—pron. fen-stare eff-nung.

Apex, *of a Gable.* The upper or highest point. The term is purely Latin, meaning the top, upper part, or summit of any object. Eng. pron. eh-pex, not ah- or awe-pakes. Syn. Fr. *Sommet* (the summit) *de Pignon* (gable)—pron. som-may deh pee-nyong, or peen-yong; Ger. *der Scheitel* (top or crown) *der Giebel* (gable)—pron. shi-tel, derr gee-bell.

Apiary, *in Garden Architecture.* (See "The Garden Architect" in text.) A house, or rather a covered stand or shed, for the reception of the hives of bees and their shelter from the weather. *Der.* Latin *apiarium*, and this from *apis*, a bee. Syn. Fr. *Rucher* (from *ruche* [pron. roosh], a hive)—pron. roo-shay; Ger. *der Bienenstand* (*Bienen*, a bee, *Stand*, a station or position)—pron. bee-nen-standt; also *das Bienenhaus*—pron. bee-nen-howss.

Apophygee, *in Mouldings.* The curve—frequently the quadrant of a circle, though it may be a lesser arc—which joins the bottom or lowest part of a column or shaft of an "order" or of a Pilaster (which see), with the uppermost member of the base—or conversely, the curve joining the top of a shaft with the lowest member of the capital. It is sometimes, though not generally, known also as the "scape" of a shaft, column, pillar, or pilaster. Syn. Fr. *Congé*—pron. kohn-gjay; Ger. *Anlauf*—pron. ann-lowf. Eng. pron. ah-poff-ee-gee (g soft).

Approach, in laying out house sites and grounds. The road or walk leading from a public or private road to the house. *Der.* From the French verb *approcher* (app-ro-shay), to bring or come near to, and this from *proche* (prohsh), near to. Syn. Fr. *Abord*—pron. ah-bore, approach, access to, landing, and this from *aborder* (ah-bore-day), to come near to; Ger. *Zugang*—pron. tzoo-gang, an avenue, an approach (from *Gang*, a walk or passage).

Apron Lining, *in Joinery.* The boarding, generally panelled, which covers the end of the steps supported by the carriages otherwise known as the string-board. Syn. Fr. *Revêtement* (clothing or covering) *de Limon* (carriage of a stair)—pron. ray-vett-mang day lee-mong; Ger. *die Beschalung* (from *beschalen*, to cover with a shell, from *Schale*, a shell), or *der Treppenbalken* (from *Treppe*, a step, and *Balken*, a beam, *i.e.* the carriage for the steps) — pron. dee beh-shawl-oong, derr trep-pen-ball-ken.

Apse, *in Architecture.* The name given to the rounded form, generally semicircular, by which the aisles or the choir of a church are terminated. This feature is a peculiarly foreign or Continental one. Churches in France and Germany, and in many parts of Italy, are met with in almost every district, displaying it. In England it is met with chiefly in churches built in the Norman style, of which it may be said to be a peculiarity. The term apse is also applied to all projecting parts giving recesses or chapels at the sides of the transepts, etc. Eng. pron. apps. Syn. Fr. *Chevet*—pron. shay-vay, or *Rond-point* — pron. rongd-pwang; Ger. *Baseliken*—pron. bah-seel-ee-kenn, so called from this being a feature of the early churches, changed from the Roman basilicas or halls of justice.

Aqueduct, *in Architecture.* A water-way or channel, either open or subterranean, or supported on embankments or arches. *Der.* From the Latin *aqua*, water, and *duco*, I lead, bring forward, or conduct—literally "a water leader or conductor." Eng. pron. ah-qweh-duct. Syn. Fr. *Aqueduc*—pron. ack- or akk-dook (oo almost as in food). In German the word is spelt precisely as with us—pron. ak-kay-dookt; but *Wasserleitung* is very frequently, if not usually employed, meaning literally "water leading," from *leiten*, to lead or guide—pron. lite-enn.

Arabesque, *in Architecture and in Ornamental Design.* That species or style of ornament used for the decoration of flat surfaces, as walls, in architectural work, and which is based upon natural forms, such as the branchlets of trees or shrubs, foliage, flowers, and fruit, but all treated in a perfectly conventional manner. All animal forms and figures, or that which has life, are rigidly excluded from all the ornamentation of the Arabesque style. (See the papers in the text of THE TECHNICAL JOURNAL under the title "The Ornamental Draughtsman," and "Form and Colour in the Decoration of Industrial Work.") Eng. pron. ah-rah-besk. Syn. Fr. *Arabesque*; Ger. *Arabeske*—pron. ah-rah-bes-keh. For the features of the Arabian architecture or building, see Moresque: the style is also known as the Saracenic or Moorish.

Arbour, *in Garden Architecture.* (See "The Garden Architect" in text.) A structure, generally of rustic woodwork, erected in part of the grounds or garden of a house, to serve as a retreat in summer-time; hence called a summer-house. On the Continent the name *kiosk* is generally given to the structure; it is there made highly ornamental, generally with "cut wood" work. For this species of carpentry and joinery see the paper on "Ornamental Woodwork" in text; and for rustic woodwork see "The Garden Architect," and Supplemental sheets illustrating Garden Building, etc. A seat under a tree, and surrounded and partly shaded with shrubs, is sometimes called an arbour. *Der.* Latin *arbor*, a seat under a tree. Syn. Fr. *Berceau* (a bower)—pron. bare-soh. Curiously enough, this word also means a cradle—that is, an inclosed space. Ger. *der Laubenbogengang* (from *Laube*, a bower, and this from *Laub*, foliage, covert; *Bogen*, bow or arch, and *Gang*, walk or course)—pron. lugh-benn-bogh-enn-gang. This is a fair example of the compounded German words alluded to in the Dissertation, although there are many vastly longer than this. Obviously the mere term would be to the reader ignorant of German a meaningless array of letters, unless we analysed it or separated its parts and gave their meaning. (See Trellis Work.)

Arcade, *in Architecture.* This term denotes an arrangement of arches in line supported by columns or pillars, the spaces between which may be open, or the back of the columns may be filled in with masonry. In the latter case the arcade is a method of ornamenting walls, as those of churches. In common language, an arcade means a street or passage covered or arched in with a glass-lighted roof. Syn. Fr. *Arcade*—pron. are-kad; Ger. *Bogengang*—pron. boh-genn-gang — from *Bogen*, a building, and *Gang*, a walk, passage, or gallery.

Arch, *in Masonry and Bricklaying.* The arrangement of stones or bricks thrown over an opening in a wall, or spanning the space between two piers or columns, and by which the weight placed above the arch and the pressure of the arch itself is thrown upon the side piers or columns, termed technically abutments. The inner or concave side of the arch is termed its "intrados"; the outer or convex, the "extrados." The stones forming the arch are cut wedge-shaped; the central stone of the arch is called the "keystone," and the wedge-shaped blocks on either side are termed "voussoirs." The first of the side stones or voussoirs from which the arch springs, or those lying on the top course of piers or columns, are termed the "springers." The width between the piers or abutments is called the "span" of the arch, and is measured on a horizontal line, called the springing line, supposed to be stretched from one abutment to the other. What is called the "rise" of the arch is the vertical distance measured from the centre of the "springing line" to the under side of the keystone. The highest part of the arch is called its "crown," sometimes its "vertex." The parts of the building or walls behind the extrados or outside of the arch, which fill up the space between the abutments and the line of "crown" of arch, are called the "haunches." The intrados, or inner or concave curve of the arch, is generally known as the "soffit." All the above terms will be found described in due alphabetical order. Arches are of different forms, and vary from the simplest of all, the semicircular or half-round, to the segmental one, and the different kinds of pointed arches in Gothic architecture. *Der.* The word comes from the Latin *arcus*, a bow. Syn. Fr. *Arc*, *arche*; Ger. *Bogen*. (For different forms of arches, see "The Stone Mason" in text.)

Arch-butment, *in Masonry.* Struts or supports with arched arrangement which spring from the buttresses of aisles in a church in the Pointed or Gothic style, and resting against the walls above, as those of the clerestory—the purpose being to relieve the direct or continual outside pressure of the central vaulting. The arrangement is otherwise termed a "flying buttress." (See illustration in Supplement, "Illustrations of Architecture and Building.") Syn. Fr. *Arc boutant*—pron. ark-boo-tang; Ger. *Steigender Bogen*—pron. stige-en-derr boh-genn (*steigender* from *steigen* — pron. stige-enn, to ascend or step up).

Arch, Gauged, *in Bricklaying.* An arch in which the bricks radiate from a common centre. Syn. Fr. *Voûte jaugée*—pron. voot- or vut-joh-jhay — from *jauge* (jhogo or jozeh), a gauge or measure, and this from the verb *jauger*, to gauge (zho-zhay).

Arch, Inverted, *in Masonry and Bricklaying.* Used in foundation work to distribute and relieve the pressure between two opposite walls. As its name imports, it is an arch reversed or turned upside down, the concave surface or intrados being the upper side nearest the surface, the extrados or convex surface being next to and resting on the ground or foundation soil. *Der.* From the Latin *inverto*, I turn upside-down, and this from *in* and *versus*, against. Syn. Fr. *Arc renversé*, or *Radier*—pron. ark rang-verr-say, rah-dee-aye (*renverse*—pron. rang-vairse—turned on one's back, backwards, and this from *renverser* [rang-vare-say], to turn back, to invert); Ger. *Umgekehrter Bogen* — pron. oom-geh-kayr-terr bo-gen (*umgekehrt*, inverse, inverted, and *Bogen*, an arch).

Architect, *in Building.* The profession which undertakes the designing or planning of all buildings, the preparation of the working drawings, the specifications of, and the general superintendence of the work to be done. Syn. Fr. *Architecte*—pron. ar-shee-tekt; Ger. *Baumeister*—pron. bough-mice-terr (*Bau*, a building, and *Meister*, a master)—literally "head or master of the works in building."

Architrave, *in Architecture.* That member of the entablature of an "order" or "style" which rests on the Abacus (which see) or uppermost member of the capital. The term is also applied to the moulding, which is sometimes carried round or attached to the outer face of an arched opening. Eng. pron. ark-ee, *not* ar-chee.

Architrave, *in Joinery.* The moulding, more or less ornate (see the paper in the text entitled "Form and Colour in Industrial Decoration" for the various kinds of Mouldings), which is carried round the sides and top of window or door openings, apertures, or voids. Syn. Fr. *Architrave*—pron. ar-shee-trahv; Ger. *Unterbalken, Hauptbalken*—pron. oon- or uun-tare-bahl-ken, houhpt- or howpt-bahl-ken (*unter*—oon-terr or -tare, under, and *Balken*, a beam, *Haupt*, head or top)—literally "the head or top beam."

Archivolt, *in Masonry,* is almost synonymous with the intrados or soffit of an arch (see Arch), as it means the interior or concave curved surface of an arch as measured from one pier or abutment or impost to the other. Where this surface is not plain—in which case the term soffit is applicable—but is broken up by projecting parts, giving the appearance of a number or cluster of arches one within the other—the term is more strictly applicable. And this feature of arches is a very noticeable one in Pointed or Gothic architecture, in which they are sometimes distinguished by the title "recessed." If the general arch is broken into two divisions, it is said to be a double recessed arch, and so on. *Der.* Probably from *voler* (vol-lay), to fly—a flying arch. Syn. Fr. *Archivolte*—pron. ar-shee-vohlt; Ger. *Unterbogen*—pron. oohn- or oon-terr-boh-gen—literally "the under arch."

Arch, Oblique, or on the Skew, *in Bricklaying or Masonry,* In this the line of face of arch is oblique, or at an angle to the line of archway, as when a railway crosses a public road at an angle not a right angle. *Der.* "Oblique," from the Latin *obliquus*, slanting, leaning to one side; "Skew," meaning the same, from the Gr. *skaios*, on the left—that is, not right—and this from the verb *skazo*, I limp or halt. Syn. Fr. *Arc de biais*—pron. ark de bee-ay-ee (*biais*, a slope, a slant, from *biaisement*—pron. bee-aize-mang, a sloping direction); Ger. *Schiefbogen* — pron. sheef-bo-gen (*schief*, sloping, from *Schiefe* — pron. shee-feh, obliquity).

Arch, Relieving or Discharging, *in Bricklaying.* The arch-segmental turned or built over a timber Lintel (which see) stretching across the top of an opening, as that of a door or window, in order to relieve the lintel from the pressure or weight of the wall above the opening. Syn. Fr. *Arc en décharge* — pron. ark-eng-day-shar-jeh (*décharge*, an unloading or discharge, from *décharger* [day-shar-jhay], to discharge); Ger. *Entlastungsbogen* (from *Entlastung* [aint-last-oong] a release or discharge, and *Bogen*, an arch).

Arch, Segmental, or Scheme, *in Bricklaying.* In this the arch is part of a circle; when the bricks are laid so that their joints converge to, or radiate from, the centre of the arch, it is called a "scheme arch." Syn. Fr. *Arc avec cintre aplati*—pron. ark a-veck (with) sang-tre ah-plah-tee (*cintre*, centre—see Arch, *aplati* from *aplatir* [app-lat-ee], to flatten or lower)—that is, an arch with a less rise than a semicircular arch, as an elliptical arch would have; Ger. *Stichbogen*—pron. steegh-boh-gen (*Stich*, a cut, and *Bogen* [boh-genn], an arch).

Arch, Semicircular, *in Masonry or Bricklaying*. As its name denotes, has the curve of its intrados or soffit the complete half of a circle. Syn. Fr. *Arc en plein cintre*—pron. ark eng pleing sangtre—literally "an arch with a full centre"; Ger. *Römischer Bogen*—pron. roem-ee-sherr boh-gen—that is, a Roman or Romish arch.

Archway. A road or path under an arch, or the arched entrance to a door. In this sense the Syn. Fr. is *Porte ennoûtée* (vaulted doorway)—pron. pohrt-ang-voot-eh; Ger. *der überwölbte Thorweg* (*über*, over or above, *Wölben*, vault, *Thor*, gate, *Weg*, way)—pron. oo-bare-voelb-teh tor-vague.

Area (Basement), The Steps or Stairs to, have for their equivalents Syn. Fr. *Escalier d'un souterrain* (*escalier*, staircase)—pron. ess-kah-lee-eh (see above); Ger. *die Kellertreppe auf dem Vorhof* (*Keller*, cellar, *Treppe*, steps)—pron. dee kell-err-trep-eh owf dem fore-hofe.

Area, *in Building*. The space of ground on which the structure is placed. *Der.* Latin *area*, an open space or piece of ground, and this from *ara*, earth or hearth. Syn. Fr. *Aire*—pron. air; Ger. *die Baustelle* (*Bau*, a building, *Stelle*, a stand, position)—pron. bough-stel-leh.

Area, *in Domestic Architecture*. The free or vacant space in front of the basement story of a building, and which is reached from the outside street or road level by steps. Syn. Fr. *Aire d'un souterrain* (underground floor)—pron. air-duhn soo-tare-ayne; Ger. *Baustelle, der Vorhof* (*vor*, before, *Hof*, a court or yard)—pron. bough-stell-eh, derr fore-hofe.

Area, *in Measurement*. The superficies or surface of a piece of ground or of a body, having length and breadth only. Area is denoted in building work as in square yards, square feet, or square inches, and is found by multiplying the length by the breadth in yards, feet, or inches. Syn. Fr. *Unité de surface* (*unité*, unit)—pron. uhn-ee-tay day soor-fass; Ger. *die Einheit der Fläche* (*Einheit*, unity, *Fläche*, extent, square measure)—pron. dee ine-hite, derr fleghe.

Argillaceous Soil or Earth, *in Excavating, or Materials*. Clayey, as an argillaceous sand is a sand mixed with clay soil, an argillaceous loam, loamy soil mixed with clay. Eng. pron. ar-geel-aish-ee-us. *Der.* From the Latin *argilla*, white clay, marl, potter's earth. Syn. Fr. *Terre argilleuse*—pron. tare or tair arr-geel-uuse—from *argile* (ahr-jeel), clay; Ger. *Thonerde*—pron. tonn-err-deh (*Thon*, clay, and *Erde*, earth, soil).

Arm Chair, *in Cabinet Making*. A chair with arms at the sides, which spring from the centre of the edges of back, and are carried forward and bent down to be joined to the front corners. Syn. Fr. *Fauteuil*—pron. foh-teuhl; Ger. *Lehnstuhl*—pron. layn-stoohl or -stuuhl (*Lehne*, a support, railing, and *Stuhl* [stuuhl], a stool); also *Armstuhl* (*Arm*, arm).

Arris, *in Building Construction*. The corner or line formed by the junction or meeting of two surfaces at angles—right or otherwise—to each other.

Arris, *in Construction*. To take off—that is, to chip, cut, or plane away—the corner of a body, making it splayed or bevelled off. Syn. Fr. *Epautrer*—pron. eh-po-tray; Ger. *Verstossen* (literally "to push forward")—pron. fare-stoss-ane. To take the arris off from a block of ashlar-worked stone has for its Syn. Fr. *Epanneler* (from *panneau*, a panel), that is, to make the angle or corner flat—pron. eh-pann-lay; Ger. *aus dem Rohen behauen*, *i.e.* to hew (*behauen*) out of or off the rough (*roh*); also *die Kanten behauen*, to hew the corners (*Kante*) or edges off.

Artificer, *in Building Construction*. A skilled workman. Eng. pron. arr-tiefis-irr. Syn. Fr. *Artificier* or *Ouvrier*—pron. arh- or arr-tee-fee-see-eh, oov-ree-eh; Ger. *Arbeiter Handwerker*—pron. aar-bite-err hand-ver-kerr. *Der.* From the Latin *artificium*, and this from *ars*, *artis*, art, and the verb *facere*, to make.

Asbestos, *in Materials*. A mineral substance of a fibrous nature, which admits it to be made into substances resembling cloth or a fibrous material like wool. It is perfectly incombustible. It is now largely used for various purposes, as packing of joints, piston-rods, etc.; and a paint is also made of it, which is used effectively in buildings, rendering wood, etc., fire-proof.

Ash, *in Materials*. A forest-tree yielding a valuable timber noted for its tough quality. Syn. Fr. *Frêne*—pron. frenn; Ger. *der Eschenbaum* (*Esche*, ash, and *Baum*, a tree), or *die Esche*—pron. dee esh-eh. (See "The Timber Dealer" in text.)

Ashlar, *in Masonry*. Where the stone used for the exterior surface of a wall is hewn and smoothed, dressed or polished, it is called ashlar work. Syn. Fr. *Pierre de taille*—pron. pee-air day tah-ee-eh or tah-ee-yuh (*pierre*, a stone, and *taille*, cutting, dressing); Ger. *Behauener Stein*—pron. bee-how-enn-err stine (from *behauen*, to cut, *Stein*, a stone).

Ash Pit, *in Domestic Architecture*. A part of the outbuildings of a house in which the ashes from the fire grates and other refuse matters are deposited. Syn. Fr. *Cendrier*—pron. sang-dree-eh (from *cendres* [sangdre], cinders or ashes); Ger. *Aschgrube*—pron. ash-groo-beh (from *Asche* [ash-eh], ashes, and *Grube*, a pit or trench).

Asphalte, *in Materials*. A hard black bituminous substance, much used in conjunction with other substances, such as broken or powdered stones, spa, etc., as a material for the formation of road surfaces, walks, etc. It is found naturally in large quantities in different countries, notedly in what are called the bituminous lakes of Eastern Europe. Syn. Fr. *Asphalte*—pron. ass-falt; Ger. *Asphalt*—pron. ass-falt.

Assemblage, *in Carpentry*. A term borrowed from the French to denote the combination of timbers forming a single framework; also the combination of two parts, as of two beams scarfed. (See "The Carpenter" in text; see also Scarf.) Syn. Fr. *Assemblage*—pron. ah-sam-blaje; Ger. *das Einrahmen* (*ein*, in, *Rahmen*, a form or frame)—pron. dass ine-raw-menn.

Astragal, *in Joinery*. A fillet with rounded edge, generally semicircular. It is a term sometimes used as synonymous with sash-bar or bar supporting the panes of glass in a window-frame. Syn. Fr. *Astragle*—pron. as-trah-gal; Ger. *der Säulenfranz*—pron. sowl-en-phrantz (from *Säule* [sow-lay], a post or pillar, and *Franz*, a band).

Attic, *in Architecture*. In Classical styles, an apartment or range of apartments of low altitude at the top of the structure. In common buildings it designates a room in the roof of a house. Syn. Fr. *Attique*—pron. at-teck; Ger. *die Dachstube*—pron. dagh-stoo-bay or -stuh-bay (*Dach*, a roof, and *Stube*, a room)—literally "a room or chamber in the roof."

Auger. A tool used in *Carpentry* to bore holes in timber to receive trenails (which see), or wooden pins, etc. It is a long iron bar provided with an eye at the upper end, through which a cross handle is passed to work the tool. The lower end is provided with a cutting screw, having a sharp point and edges, which, as the handle is turned round by the workman, keeps entering into or descending into the timber, the larger part of the screw cutting with its sharp edges the hole in the wood. The twist or pitch of the screw enables the cut chips to clear themselves from the hole as it is formed—these rising up to the surface, from which they are swept away from time to time by the workman. Syn. Fr. *Tarrier*—pron. tar-ee-air; Ger. *der grosse Bohrer*—pron. derr gros-seh-bore-er, meaning a borer for great or large, as a gimlet is for small holes in timber, which is simply *der Bohrer*, the borer.

Avenue, *in Laying-out Grounds or Garden*. A walk generally bordered by trees or shrubs. *Der.* The word is purely French, and is derived from the French *avenir*, a prospect, and this from the verb *avenir*, to happen, as in looking forward for something to happen, in prospect—pron. ahv-neer. The French is derived from the Latin *ad*, to, and *venire*, to come. Syn. Fr. *Avenue*—pron. av-neugh; Ger. *der Baumgang* (*Baum*, a tree, *Gang*, a walk)—pron. boughm-gang.

Aviary, *in Garden Architecture*. A structure erected in the grounds or garden of a house, in which birds are confined for display. It is composed of open wire-work or wire netting for the upper part, with a solid or enclosed base. The interior is fitted up with perches, or in large aviaries a tree is inclosed, or small shrubs. *Der.* From the Latin word *aviarium*, and this from *avis*, a bird. Syn. Fr. *Volière*—pron. vohl-ee-air (from the Latin verb *volere*, to fly—that is, a contrivance to prevent the birds flying away, or to show off their flying or moving about while encaged. Ger. *das Vogelhaus*—pron. dass fog-el-house—from *Vogel*, a bird, and *Haus*, a house.

Awning, Window, *in Domestic Architecture*. A covering of wood, sometimes of thin sheet-metal, placed in front and at the upper part of a window to keep off or temper the sun's rays. It is frequently made a permanent part of the building, and is more or less ornamented in keeping, or otherwise, with the general style of the structure. It is also in some patented contrivances so arranged that it can be shoved or pulled back into a recess so as to be quite concealed when not in use. The term is a corruption of the Old English word *haihelian* or *helan*, to cover over or up. Syn. Fr. *Tente d'un fenêtre* (*tente*, tent or awning, *fenêtre*, a window)—pron. tangt duhn fay-natre or fay-nate-uh; Ger. *Fenster Dachung* (*Fenster*, window, and *Dach*, a roof)—pron. fane-stare dagh-oong.

Axe, *in Carpentry*. A steel edged tool used for cleaving and splitting wood, and for taking off the surface in a rough way. The front edge is generally slightly rounded, and of steel to the breadth of an inch or so. The handle is inserted in an eye near the back, and is at right angles to the side of the tool. The extreme back beyond the handle eye is formed into a projecting part with a flat steeled face; this part, termed the "poll" of the axe, serves as a hammer for driving spikes or trenails, large nails, etc. A small light axe under two pounds weight is termed a "hatchet," being used with one hand only. The Old English form is *eax*, the Icelandic *axa*; the Greek word is *axine*, and the Latin *ascia*. Syn. Fr. for the whole tool, handle included, *Hache*—pron. hahsh; for the head or metal part, *fer de hache*—pron. fare duh hahsh; Ger. *die Axt* or *das Beil*—pron. dass bile.

Axis, *in Masonry and Carpentry*. The assumed or imaginary line passing through the centre of base to centre of apex, as of a circular vault or dome; the centre line of a body. *Der.* Latin *axis*, north or south pole of the globe. Syn. Fr. *Axe*—pron. ahx; Ger. *die Mittellinie* (*Mittel*, middle or centre, *Linie*, line)—pron. der mit-til-leen-e-eh.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

1. The Transmission of Power by Belts.

THE reader will find in the series of papers in the text under the head of "The General Machinist," the various points described connected with the special department of Practical Mechanics of transmission of power from one point to another, or the communication of motion. We have here to give a place to a number of facts and figures connected with the general subject, derived from a wide variety of sources, which could not for more reasons than one, find a place in the papers referred to. The primary elements of belt driving gear are the shaft and the pulley, and the media of conveying the power of one set of these to another set or to other sets—namely, the belts made of various substances. As forming a distinct part of the practical work of the mechanic, various facts and figures will be given in a future series of paragraphs under "Shafts and Pulleys, or Rope Driving Gear," confining this to the subject of Belts. Up to within a comparatively recent period the transmission of the power of, or the "taking off" of the driving power of the shaft of the prime mover, as that of a water-wheel or steam-engine, was done through the agency exclusively of toothed-wheel gear, as spur wheels and pinions; and to the leading shafts, such as the vertical shaft of a cotton factory, conveying power to different floors, by bevel toothed gearing or by mitre wheels. (See the series of papers in the text under the title of "The Building and Machine Draughtsman" for different kinds of toothed-wheel gearing; and also the series entitled "The General Machinist.") The method of communicating motion by means of belts, straps, or bands, or by cords or ropes, to which mechanical appliances Professor Willis gave the name of "wrapping conductors" of power or motion, was confined solely to the driving of the smaller machines, and parts of machines requiring comparatively small power. But of late years a very remarkable change in mill and machine engineering has been the substitution of "belt" and "rope" gearing for that of toothed wheels, to which latter the generic name of "gearing" was given, indicative of the exclusive use of it for a long course of years. Of these two methods, that of rope-gearing may be said to be the latest, and in the opinion of some it promises to supersede belt-gearing, although as yet the employment of belts is largely in excess of ropes. The two systems have, however, been so largely introduced, that the largest mills are geared upon these principles, which would but a few years ago have been driven by the old system of toothed-wheel gearing. The reader will perceive, then, that a large amount of practical technical interest is involved in the subject of the present series of paragraphs, as named in our title. It is, perhaps, scarcely necessary to say that the systems are not applicable to certain classes of machinery, which do not fulfil the conditions necessary to secure their highest development. What those conditions are will be stated in another "Note."

2. Strength of Belts.

In this paragraph leather is the only material considered, as this at one time was exclusively used for belt gearing—and even now, when it has rivals in the market, is still chiefly used; the principal experiments made by various practical authorities, and the rules deduced from those and from a wide range of experience, have all been in connection with it. It will easily be understood, from the nature of the material—not only from the quality or character of the hides or skins from which it is in the first instance obtained, but also from the way in which this is afterwards treated, or the leather manufactured—that very considerable differences are likely, indeed certain, to be found in the strength of leather belts to enable them to withstand the strain to which they are subjected when wrapped round pulleys in that state of tension required to do the work. And in practice it is found that different parts of the hide give different qualities of leather, and that those again vary in their value when used for belting. Again, as showing the young mechanic how, in even what appears to be such a simple department of mechanical work, the mechanic has to think about and find out a great number of points, it has to be stated—what from its importance will be more fully gone into in a succeeding note—that the mere way of placing a belt on its pulleys affects its working value; while the mere strength or capability of the leather to resist rupture does not give working efficiency in the highest degree to the belt made of it. Thus one part of the hide will give a leather which will take a greater force to rupture it than leather made from another part of the hide, yet that which is the weakest is better adapted for the working circumstances of belting than the strongest. Many points have, therefore, to be considered in determining the value of leather for belting, in addition to its mere textile strength, and it is those points which constitute the real working strength of belting—meaning by this term all the good conditions necessary to ensure the safest and the most economical working in practice. The figures which are accepted by mechanics as indicating the value of leather to resist a rupturing strain have been found, therefore, as might be anticipated from the above statements, as the result of experiments and of practice with leather of good average quality made from the best hides, and oak-bark not chemically tanned. And although it is necessary for the mechanic to understand what he is doing, and what the value of his materials really is, and figures or data as to strengths are necessary, still it is so far fortunate for him that even when subjected to severe strains, such is the good quality of leather which is honestly made, that he will find that it will as a rule practically not break or rupture—and this even when placed under somewhat unusual conditions of continuous working. The most complete investigation into the subject of the belts is that made by General Morin, the well-known French scientist; and so highly is his report esteemed, that it is issued under the authority of the French Institute. A recommendation the value of which is shown not only by the fact that nearly all experimenters who followed Morin have availed themselves of his investigations, the accuracy of the results of and practical deductions from which is shown that all subsequent experience has verified them in nearly every respect. Morin showed that for continuous working—that is, under the circumstances of a working day—a leather belt may be made to bear a tensile strain—that is, a strain or force tending to separate its fibres and tear it asunder—of 0·551 lb. per ·00155 square inch of section. This is equal to 355 lb. per square inch of section of the leather. The young reader must, however, note that this is the working strain to which the belt may be subjected, and is quite distinct from the ultimate strength or the breaking strain of the leather, which is much higher, varying from eight to twelve times this working strain now named. A fair average of ultimate or tensile strength of leather may be taken at nine times the above working strain. This will give a breaking strength of 3195 lb. to the square inch of section. Whatever be the tensile strength of the leather proposed to be used—and this, from what has been said, will be found to vary according to circumstances—the working strain should not exceed one-tenth of the ultimate or tensile strain; and it will be safer if a wider margin or factor of safety be employed—say one-eleventh of the tensile strain. These would give either 319 (say 320) or 290 lb. to the square inch of section of belt as its safe continuous working strain, which is less than the 355 lb. of Morin. This latter, which is generally followed, however, gives an average working strain of 55 lb. for each inch of width in a belt of which the thickness is $\frac{3}{16}$ths of an inch—which may be taken as the usual or average thickness of belts. A safer strain will be 45 lb. to the inch in width of the belt. Theoretically, a belt stretched and running over pulleys is "endless"; but in practice there are two ends which have to be joined before the belt can be used and become practically endless. This junction of the ends of a continuous or endless belt introduces two conditions in the belt considered as a whole or a single piece. There must be some difference between the solid part of the belt and that at which the junction is made. And this difference will depend upon the method adopted to join or secure the two free ends together. As a rule—we might say universally, without exception—this difference is all against the joint: that is, the belt is weakest at the junction. Some have claimed for their methods of joining that they are so efficient that the belt is as strong at the junction as at the solid part, while others have gone further and claimed for their methods that they give actually a greater strength. Be this as it may, the general experience is that the junction of the two free ends of a long band or belt in order to make it continuous or endless is the weakest part. Keeping out of consideration for the present special methods of joining belts, most of which are the subjects of patents, the methods in use may be reduced to two—riveting and lacing. The young reader, remembering the mechanical aphorism that the "strength of a machine lies in its weakest part,"—a statement which in its seeming paradox has puzzled sorely many a beginner,—will thus perceive that the real working or continuous strength of an endless belt really lies in the capability, not of the solid part, but in that of the joined or spliced part, to resist rupture or a breaking strain. Experiments have been made to determine the strength of the joined parts or riveted or laced parts, as compared with the solid parts of a belt. From these it appears that, taking the ultimate breaking strength per inch of width of the solid part at 675 lb., that of the riveted part was 382 lb., and that of the laced part 210 lb. The weakest part of a belt is that in which the lacing holes have been pierced, which is usually weaker than the actual thong or lacing leather used. The difference between the strength of the punched leather belt with copper rivets and a belt with lacing or thong is greater in the case of the riveting, the copper used for the rivets being so much stronger than the lacing. This is shown from the above to be nearly three times in favour of the riveting method, notwithstanding which many mechanics prefer the lacing method of joining ends to the riveting one. Taking one-third of the above strains as a safe margin or factor of safety, we have for the solid part a strength of 225 lb. to each inch of width (or say 220 lb.) as that which we may expect from ordinary belts, 127 lb. as the strength of the riveted parts, and 70 lb. only of the laced parts. A thoroughly safe working tension of the latter may be put down at 45 to 50 lb.

3. Portland Cement Concrete.

The extensive use of this substance in a wide variety of work has been a marked feature in the practice of building construction during the last quarter of a century. Where the best results are desired in concrete work, Portland cement has almost completely superseded other cements long used, of which "Roman" was the best known; and the same may be said of concretes made with hydraulic mortars—that is, limes mixed with what at one time only were described as "cements," such as the well-known "tarras" and "puzzolona." The term "cement" in the building constructive sense includes all mortars which have the property of "hardening" under water or "setting" firm and hard in the air. The "Roman" cement, which at one time had the greatest reputation, and is still highly thought of by some, was frequently described as "Parker's cement," from the name of its inventor. Mr. Parker discovered that by calcining the hard or pebbly calcareous nodules found in the Isle of Sheppy, found also largely in other districts, and at Boulogne, in France, and forming a powder, he produced an hydraulic mortar closely resembling the well-known puzzolona so largely used by the Romans. Roman cements generally are formed by burning at a low temperature argillaceous limes found naturally existing. The "Portland cement," so named from hardened masses of them having the external appearance of Portland building stone, are produced by burning or calcining at high temperature masses of clay and limestone mixed in certain proportions, and afterwards grinding them into a fine powder. In some districts stones or hard nodules are found existing naturally, which are found when calcined to produce a powder under grinding possessing all the properties of good Portland cement so-called. The following tables give first under A the constituents of samples (1) of English Roman cement; (2) of Portland cement, made by one of our first manufacturers; and (3) of clays suitable to mix with limes in order to make Portland cement. The table B shows (1) the relative strength of bricks made of Roman and Portland cement alone, and (2) of bricks made with those cements, but mixed with sand.

TABLE A.

Constituents.	Roman Cement.	Portland Cement.	Clay (Medway) for mixing with Limes or P. C.
Lime . . .	58·88	59·06	0·75
Magnesia . .	5·00	0·82	
Alumina . .	6·40	6·92	11·64
Oxide of Iron .	4·80	3·41	14·80
Silicic Acid . .	23·83	24·07	68·45
Sulphuric Acid Lime . .		2·85	
Potash . . .		0·73	1·90
Soda . . .		0·87	2·10
Clay . . Sand . .		1·47	

TABLE B.

Roman Cement Pure.	Portland Cement Pure.	Roman Cement 1 part, Sand 1 part.	Portland Cement, 3 parts Sand to 1 only of Cement.
Breaking strain or Strength . . 476 lb.	1372 lb.	420	420

The bricks were six square inches in section; and it is worthy of note that when the pure Portland cement was immersed in water for twenty-four hours, its breaking strength was increased in the ratio of 15 to 13.

Portland cement is, however, not only much stronger than Roman cement, but when mixed with water hardens under water not only in a much shorter space of time, and "sets" also much more quickly in the air. But, what is of great importance in a constructive point of view, it acquires a gradually increasing hardness both in air and water till the maximum is reached. These properties, and the ease with which it lends itself to the making of different classes or kinds of "concrete"—that is, when used to cement other and foreign bodies, as broken stones, bricks, glass, gravel, pebbles, clinkers, sand, and indeed every kind almost of hard incombustible materials—has given a practical value to Portland cement, which it is difficult to over-estimate. In a succeeding note we shall give a variety of practical remarks as to its use in construction, with some hints as to its quality, durability, etc., etc.

4. Gaseous Fuel as against Solid—that is, in its Ordinary Condition.

Of late years several systems have been introduced with a view to using gaseous fuel in place of coal and coke in manufactures. And they have been so successful that they are in daily use on the large scale, in several branches of our manufactures, of which that of the iron and the steel trades are the most notable examples. Descriptions of the best of these—of which the Siemens Regenerative Furnace is the leading type—together with ample illustrations of the forms of furnaces and constructive appliances used, will be found in the paper in the text which it is our intention to give under the title of "The Furnace Builder and Designer." In this paper also the theoretical as well as the practical points involved in the whole question, as between the use of solid fuel—that is, coal, for example, in its ordinary condition—and gaseous fuel will be fully discussed. Meanwhile this "note" is intended to convey some of what may be called the elementary points of the subject chiefly in their chemical aspect. Excellent results have been obtained by using carbonic oxide gas, CO, which burns with little light but with an intense heat, forming carbonic acid gas, CO_2; and several large firms have banished coal and coke entirely from their works as fuel, except for the production of the gas itself. When coke is burnt with an *excess* of air, carbonic acid is formed; when now this is passed over heated coke the CO_2 splits up, takes an additional atom of carbon, and is converted into carbonic oxide, thus: $CO_2 + C = 2\,CO$.

When common coal is burnt, as in the domestic fireplace, the chief product of combustion is carbonic acid gas, CO_2, provided that there be ample access of air and a good heat; if both these conditions be absent there is very little CO_2 formed, but much volatile matters—such as hydrocarbons, etc. In the latter case incomplete combustion has taken place, or in fact simple distillation—the coal simply splitting up into carbonic oxide and various organic compounds,—the exact nature and quantity depending on the amount of heat applied, and on the kind of coal burnt.

Thus the heat evoked during this incomplete combustion is very small—the heating-power being in fact wasted. If these products be collected they will be found to burn readily, emitting much light and heat; but if thoroughly burnt, the products of combustion if *again* collected will be found quite incapable of burning. When coke instead of coal is burnt, a similar thing occurs, but the case is much simpler; for coke, having been already subjected to distillation, is much simpler in composition than coal, and hence its products of incomplete combustion consist not of a variety of compounds, but, practically speaking, wholly of carbonic oxide gas, CO.

Now, in ordinary coal and coke burning, a comparatively large proportion of the heating-power is allowed to escape up the chimney, owing to incomplete combustion, due in most cases to insufficient supply of air. The best method of completely preventing this loss—*i.e.* of getting all the heat out of the coal or coke which it is possible to get—is to convert the coal or coke first into some kind of gas or mixture of gases, by applying the proper amount of heat, and then burning the gas separately and completely. In the case of coal this is already done, in the production of coal gas; but this is a subject treated elsewhere, and we here refer only to coke. From coal may be produced a gas possessing either great heating and little lighting properties, or a gas having great illuminating but slight heating qualities, or a gas of intermediate character, chiefly by regulating or adjusting the heat at which the coal is distilled. In the case of coke, however, only one quality of gas capable of burning may be obtained by heating—namely, carbonic oxide gas, possessing great heating but almost no illuminating qualities. It is this gas which is now largely employed to take the place of coal or coke for heating purposes: it passes into the fireplace of the boilers, and burns with air, giving out an intense heat, of course without soot or ashes, the sole product of combustion being pure carbonic acid, CO_2, of any kind, and which demands no periodical cleaning out of boilers. The gas is produced from the coke in an exceedingly simple manner. A tall cylinder is filled with coke and heated from below, an *excess* of air being admitted at the bottom. The coke there *burns*, forming carbonic acid; this, on passing upwards through the heated masses of coke, takes up more carbon, and is converted into carbonic oxide, which is passed into the boilers for combustion.

5. Utilization of Alkali Waste.

It is well known that in the manufacture of soda by the Leblanc process there is a large amount of waste, which, collected as "alkali waste heaps," is a cause of annoyance to the public, a source of loss to the manufacturers, and forms unsightly objects hundreds of acres in extent, in the alkali making district. (See the paper in text "The Alkali Maker.") One of the most important questions in modern alkali making is, how not only to get rid of this troublesome material, but how to do it profitably. Until recently this was an unsolved problem; now the wide adoption of the ammonia-soda process of alkali-making is so serious a competition to the old Leblanc process, that the latter can now be carried out profitably only by dint of great economy, one of the principal items in which is the utilization of alkali waste. Several processes have been tried with more or less of success for the accomplishment of this object, but none have been more successful both in a scientific and a commercial sense, than that known as the Schaffner and Helbig's process. This method may be described in a succeeding note.

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THE PRACTICAL NOTE-BOOK OF INDUSTRIAL SCIENCE FOR HOME STUDY.

(1) What may be called the minor details of the various branches of industrial work comprise within their range an almost endless variety of practical facts and suggestive circumstances closely connected with, and bearing to a large extent on, the success of the work done in them. Numerous, and in one sense, taking them in the aggregate, inexhaustible, they are nevertheless being daily added to as the range or capability of the different branches becomes extended, and the experience in working them widens. Many of these details never get published, as the phrase goes, not even in the limited sense of becoming known to others than the individual to whose superior skill, knowledge, or happy thought, the improved detail is due. This individual reticence is in many cases not due to a selfish desire to keep to themselves what would be beneficial to others, but simply because they modestly believe that what they have got to tell is really not worth the telling. Other details and facts, and many of great practical value, having the same origin, meet with a more useful fate: they are made known by the less reticent discoverers to their intimate friends and acquaintances, in many cases with a real desire to benefit others; in some cases merely for the sake of talk or of self-glorification. Still, even in this case, their publication so called is of the narrowest. But scattered throughout an endless variety of publications properly so called, in the pages of the transactions of scientific and engineering bodies, in pamphlets and papers issued by the discoverers of new processes or the inventors of new machines, and even in many of the best of our trade catalogues, a vast variety of facts connected with industrial work in every branch, of practical details of great value, may be met with by the painstaking searcher after good things, or are come incidentally across by those who for some particular purpose are consulting the records of scientific or industrial work. But, although they may thus be met with, they as a rule lie quite beyond the reach of the many. They are not purchasable, or, if so, not easily, by the ordinary class of readers; and their mere numbers and cost would preclude the majority of book-buyers from possessing them. And even where the sources of information—and we have by no means exhausted the list—are accessible and available, their mere numbers would deter the majority of readers from the attempt to look over their pages, even in the most desultory manner. All the more easily would they be disheartened in the attempt, granting they were acquainted with the fact that there was something worth looking for, by finding that the looking involved great labour, inasmuch as in very many cases such practical details bearing on industrial work were mixed up with matter not always cognate—in many cases the reverse of cognate—with the particular subject in which the searcher was interested. The only way in which practically and with comparative ease these treasures of industrial and scientific work can be disentombed from amidst the mass of other and often of foreign matter, is through those who, like ourselves, have frequent occasion, for one purpose or another, to be "searching the records" of too often obscure and difficult-to-be-met-with sources of valuable information, and who at the same time are aware that amidst the matter of innumerable pages many facts of great practical value may lie hidden, only to be noticed by those who have a keen eye for the practically useful. But some young reader may ask, How is it that such details, practical as beyond a doubt they are, are not to be found in such special papers as, for example, those which go to make up the bulk of this present work? To this the reply is as ready as it is on consideration obvious. To name all the details, to give all the suggestive hints which might be given in a special paper on a special subject—as, for example, "Calico Printing" or the "Steam Engine"—would so lengthen it out, or extend it, that the space available for two or three subjects would be taken up by one only. No paper, however complete it may be in the sense of its giving the leading and essential features of the subject, can be absolutely exhaustive, inasmuch as daily experience, and daily invention of machinery, and discoveries of new processes and improved methods of working, are daily adding to the bulk of information. These, as we have said, are so numerous that to find a place for them would make each special paper altogether too voluminous to have a space allotted to it. But in addition to all these sources of the valuable facts, hints, and suggestions we have named, there are many subjects of great scientific and industrial interest, for the treatment of which, as *special papers*, space cannot be found in the text of a work like the present. Taking, then, all the sources of information we have named, the reader will perceive that there is a mine of it, so to call it, vast enough and rich enough to yield, if explored, much "precious metal," which otherwise might be left alone and lost, so far as many of our readers were concerned. For years the writer of these lines has been searching in this mine; and if, like other workers in hidden regions, he has brought up to the surface what is of little worth, there is in the bulk of what has been collected much of great value, which through the present medium will be presented to the reader of THE INDUSTRIAL SELF-INSTRUCTOR FOR HOME STUDY. In addition to this the writer hopes to be able to give notes on subjects of practical interest which, as above stated, could not form the subject-matter of a special paper in the text. We proceed, then, to our *pleasant* duty—for it is true in all things that it is more blessed to give than to receive—with this proviso, however, that this, the first presentation of matter dug from the mines we have named, must not be taken as a sample of the gifts yet to come; this our first paper being almost wholly introductory. And here one word as to the plan of this department of our work. No attempt at classification of subjects has been attempted. Apart from inherent difficulties, consequent on the diversity of the subjects to be dealt with, and the necessity to economise space where there are so many demands made upon it, the ranging of the different paragraphs under special heads or classes would tend more to confuse than to facilitate ready reference to them. All that is practically necessary to make reference fairly easy will be gained by simply numbering the paragraphs. And this is necessitated by the fact that, while all the subjects will be treated with great brevity, some will demand more than one paragraph, and as the different paragraphs may be given at different times, the connection between them will be easily made out by reference to given numbers.

(2) Those who have had much to do with the working of machinery, and who are observant of its facts, know well that the difference between the working of one machine economically, and that of another which takes more power to drive it, or displays rapid wear and tear, is caused by something very simple—what thoughtless men would designate a trifle. Amongst these trifles, so called, may be placed "lubrication," which may be defined as the art of lessening friction or the rubbing of moving parts, with consequent wear and tear and loss of motive power, by the use of greasy or oily substances applied to the parts. Lubrication in itself seems to be a very simple matter indeed, and one which would not demand any very special care. But the young reader may, nevertheless, be surprised to learn that it is one which involves so many points that its consideration may be said to be a new science, as the designing and making of the appliances or apparatus its careful carrying out demands has created a new speciality in mechanical engineering. But he will be surprised to learn, further, that the new views of the subject quite recently put forward by eminently practical men will probably altogether revolutionise our notions of, and modes of dealing connected with, "friction." From what is said on this special subject in another part of our work, under the title "Recent Research in Friction," the reader will see that this subject has long formed a species of battle ground in which have been fought out the conflicting theories and statements of different writers. From these a great deal of complexity has arisen, not lessened by the mistake made so frequently by scientific men, assuming that all machines are alike, forgetting that the *conditions* under which *each* machine works constitute, in fact, the circumstances of working which alone require to be considered. By thus taking each case as it is, to be dealt with by the machinist, many of the difficulties which have hitherto attached to calculations about friction can be got rid of. Friction, from the machine point of view, is, it is well known, the rubbing of two metals in contact with or against each other, and the different metals bringing into existence different effects, different coefficients are employed in calculations. But it is also well known that by interposing the lubricant between the metals much of the rubbing or frictional effect, so productive of loss of power and wear and tear, is done away with. Perfect lubrication is where there is a complete ring of oil round the revolving parts, or a film between the surfaces, so that the metal swims in a bath, so to say, or floats upon a bath of oil or lubricating substance. Here there is a complete separation of the one metal from the other, so that practically, and taking a common-sense view of the subject, what in this case is the point with which the machinist has to concern himself, is not the friction of the metals, for they never touch each other, but the oil, grease, or other lubricant which separates them and prevents them from rubbing on each other—in fact, the friction of metal and oil or grease. If we possess a good lubricant, and can manage to apply it properly, we have got all we wish. And in getting it we get rid also of all those complicated and, to the young mechanic, too often confusing calculations and considerations which have made the subject of friction such a bugbear to many. The reader will perceive, if these views are accurate, how much simplified the subject is, and how investigation and experiments must go in quite another and an easier direction than that of the past. It must not, however, be assumed that the lubrication is itself altogether a simple matter. What points connected with it are likely to be practically useful to our readers will form the subject of future paragraphs.

FORM AND COLOUR IN INDUSTRIAL DECORATION (*see Text*).

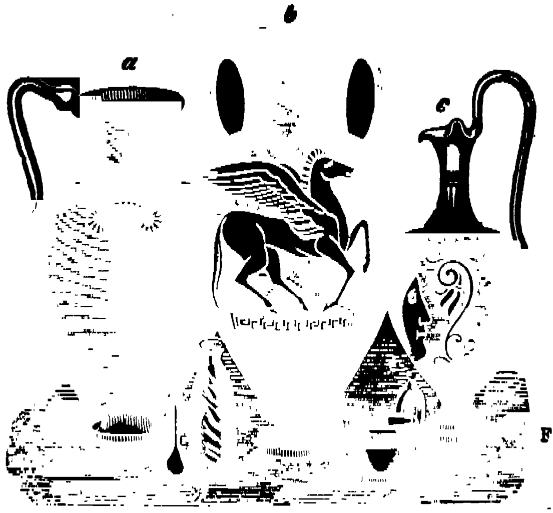


Fig. 1.

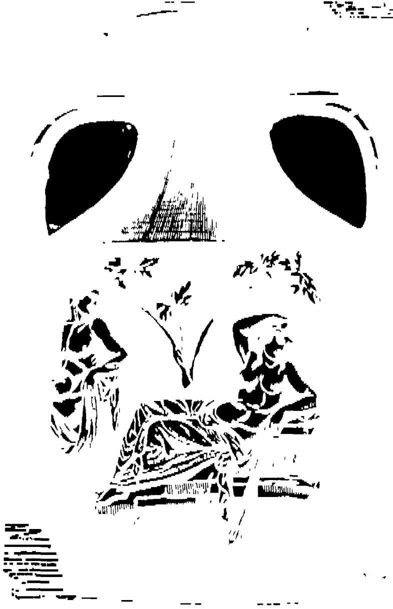


Fig. 2.

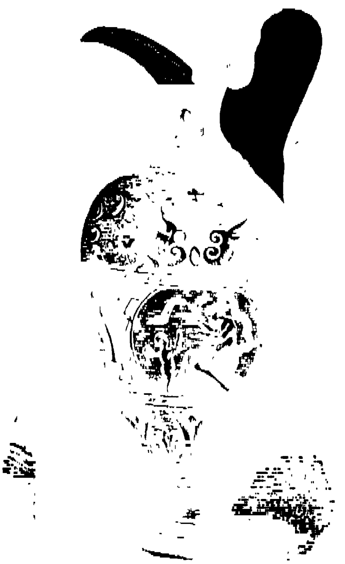


Fig. 3.

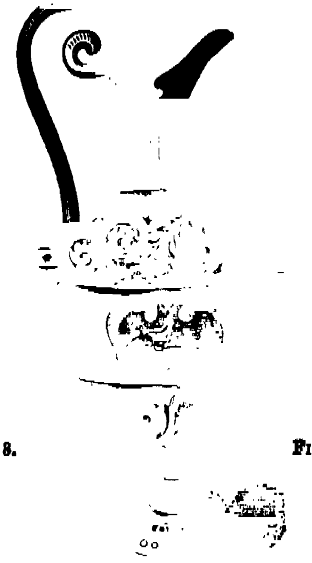


Fig. 4.

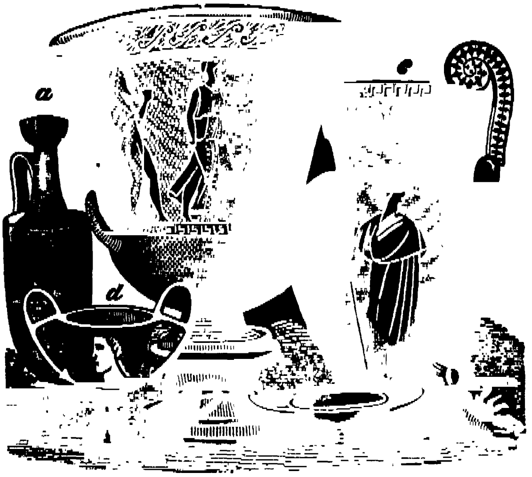
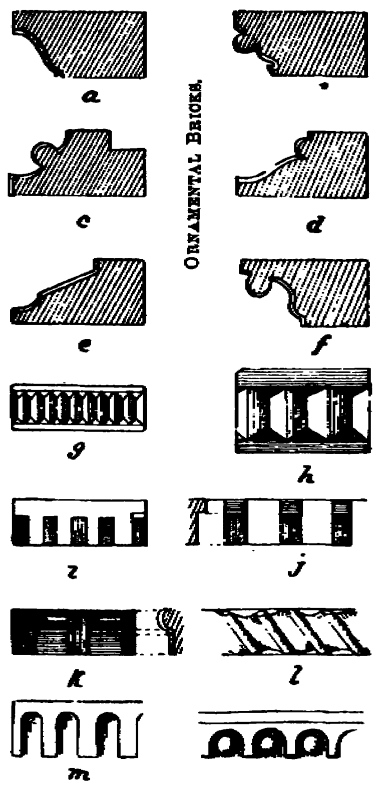
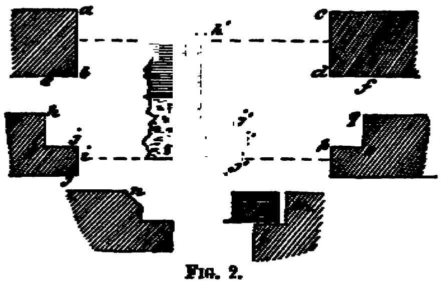


Fig. 5.

VARIOUS FORMS OF ORNAMENTAL AND HOLLOW BRICKS.



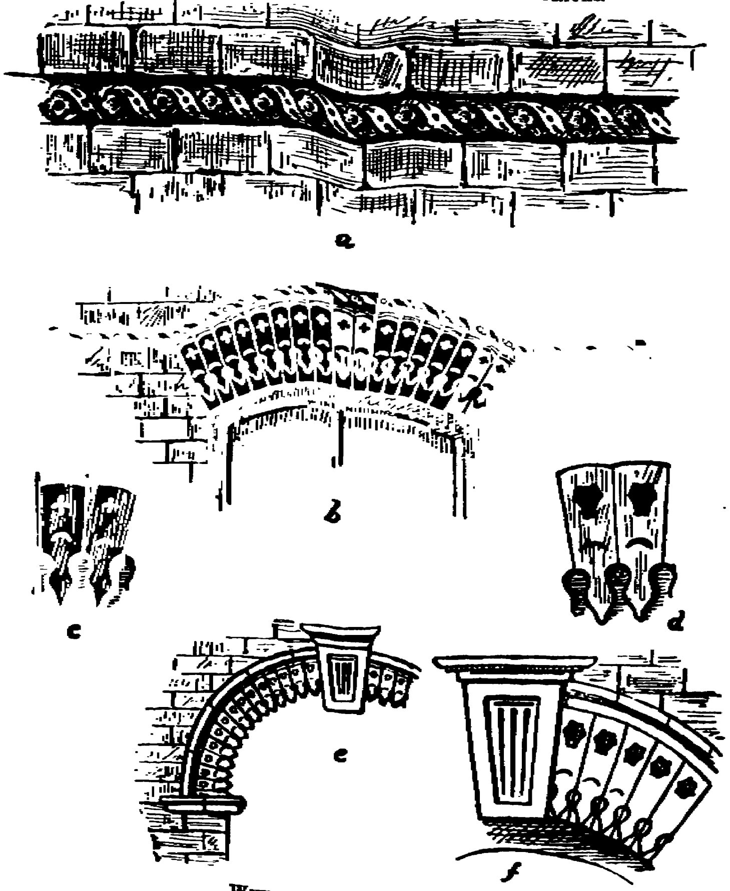
ORNAMENTAL BRICKS.



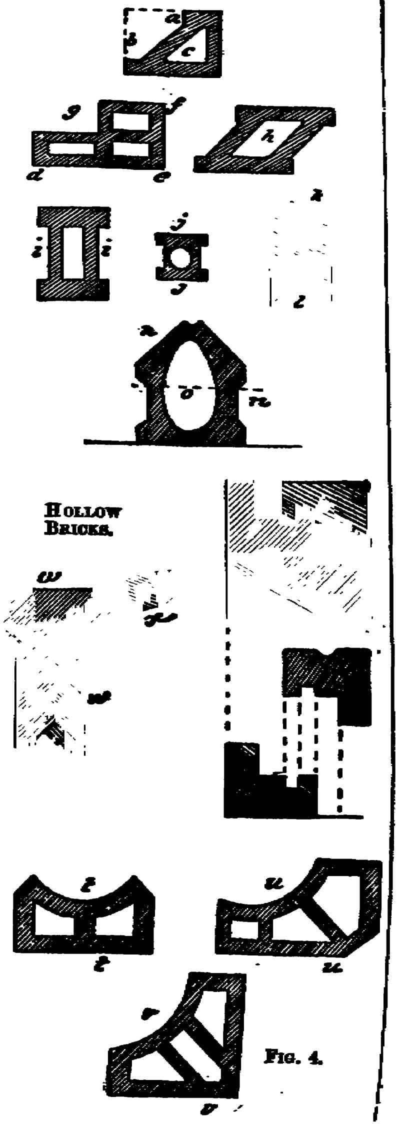
FIG

REVEALS.

FIG. 2.



WINDOW AND DOOR HEADS.
FIG. 3.



HOLLOW BRICKS.

FIG. 4.

THE JOINER (*see Text*).

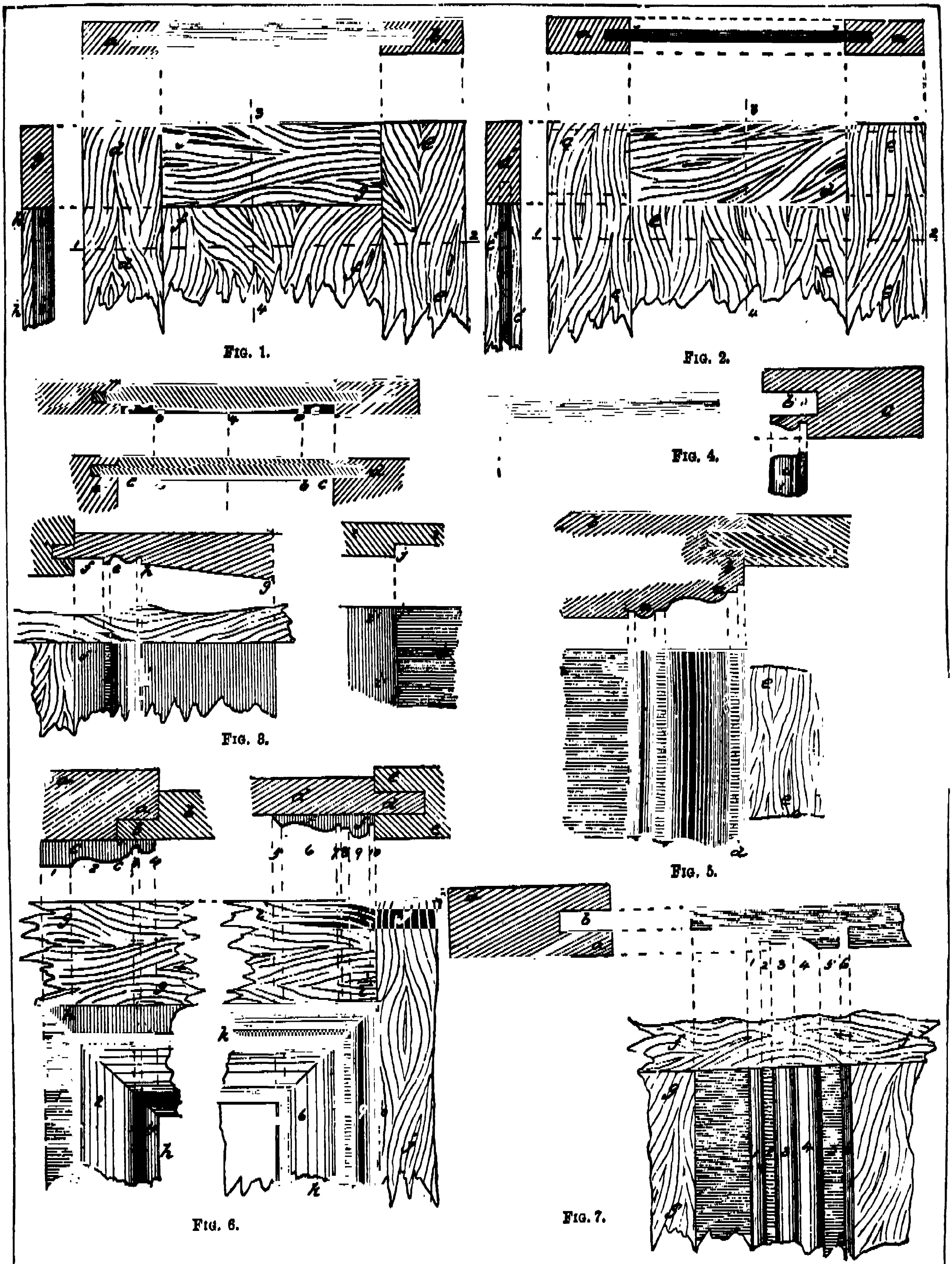


FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

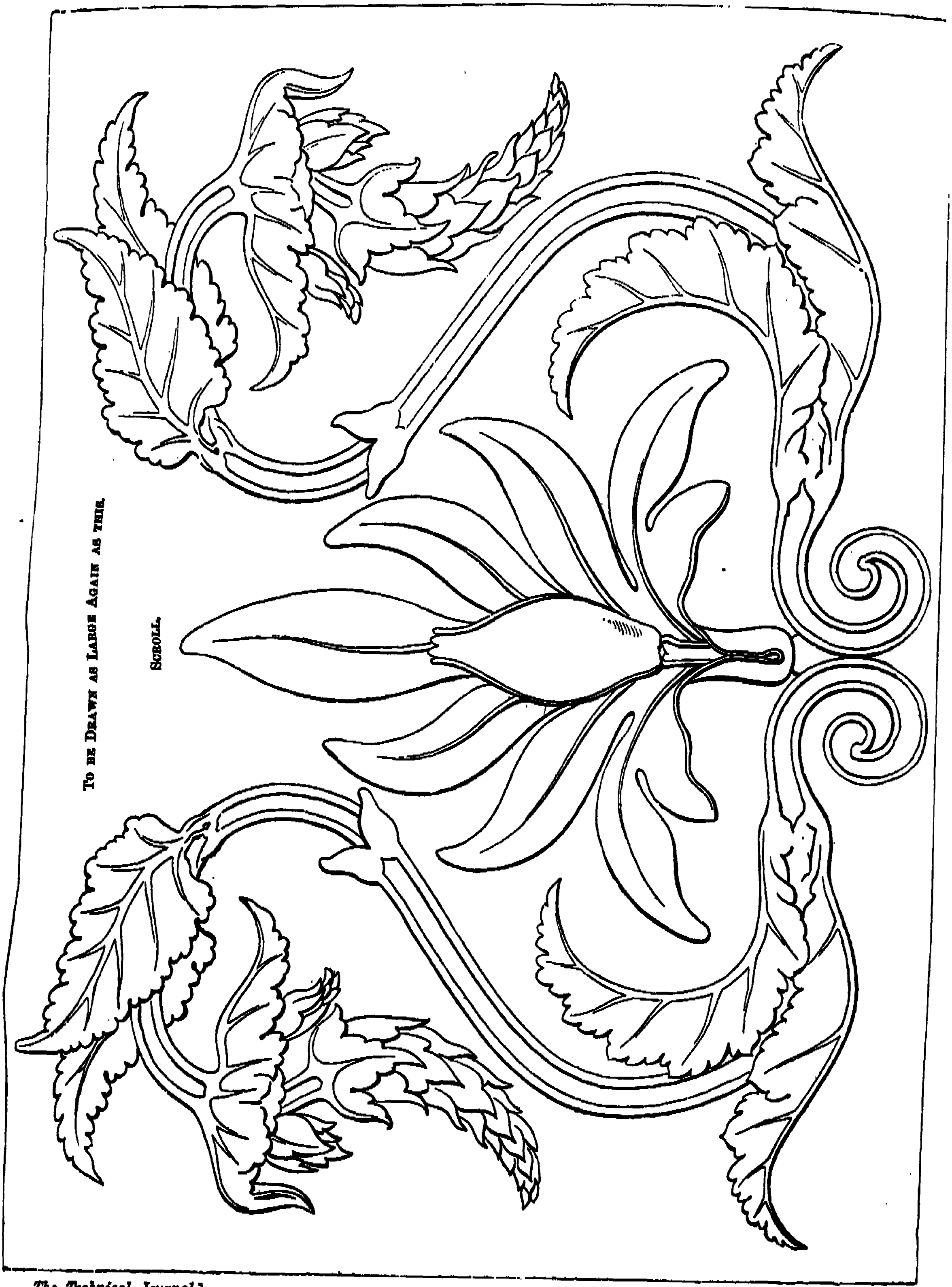
FIG. 5.

FIG. 6.

FIG. 7.

VARIOUS FORMS OF PANELS AND PANEL MOULDINGS.

THE ORNAMENTAL DRAUGHTSMAN (*see Text*).



SCROLL.

TO BE DRAWN AS LARGE AGAIN AS THIS.

THE BRICKLAYER. *ORNAMENTAL BRICKWORK. DIFFERENT FORMS OF BRICKS (see Text).*

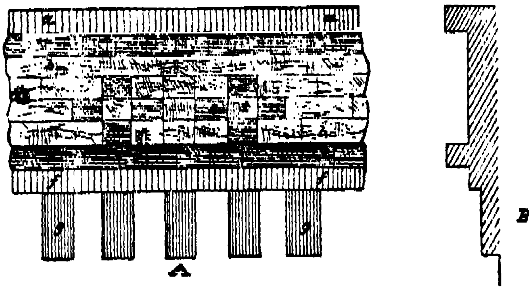


FIG. 1.

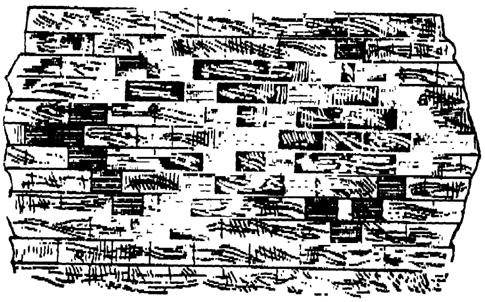


FIG. 2.

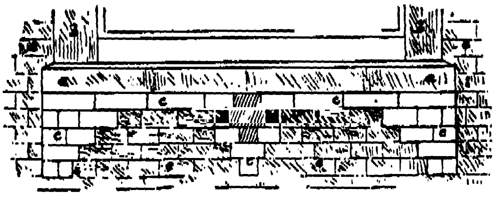


FIG. 3.

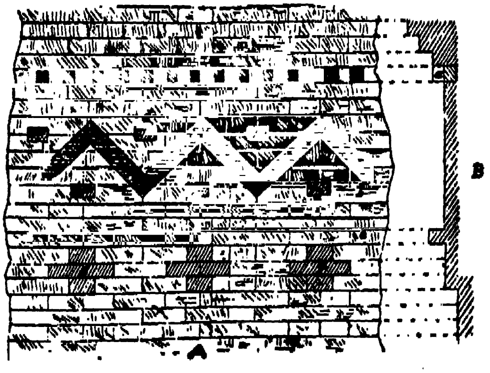


FIG. 4.

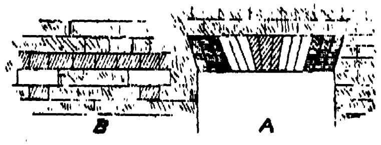


FIG. 5.

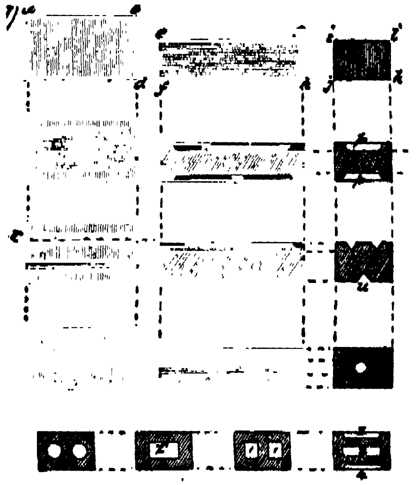


FIG. 6.

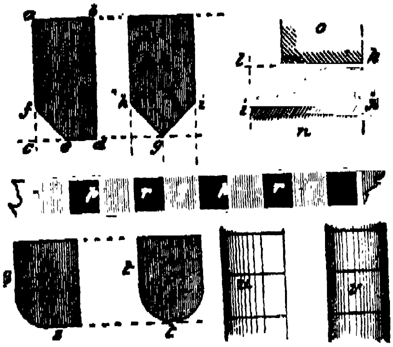


FIG. 7.

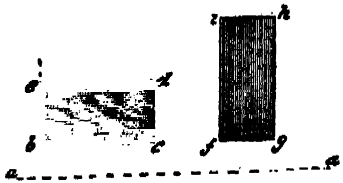


FIG. 8.

FORM AND COLOUR IN INDUSTRIAL DECORATION *(see Text).*

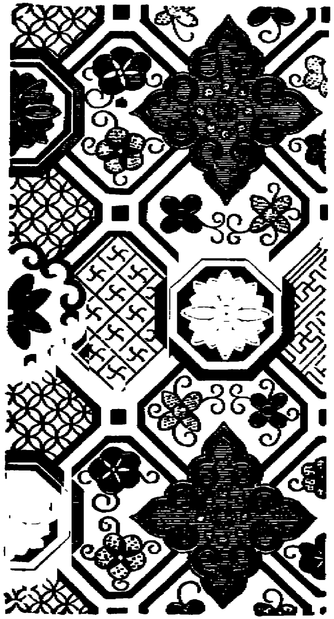


FIG. 2.

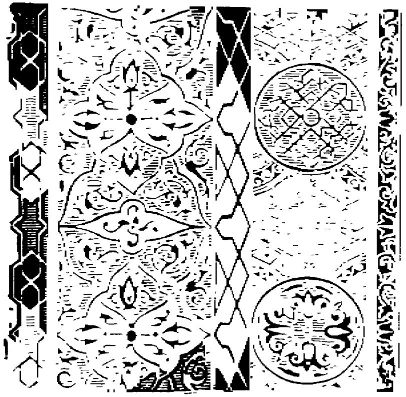


FIG. 3.

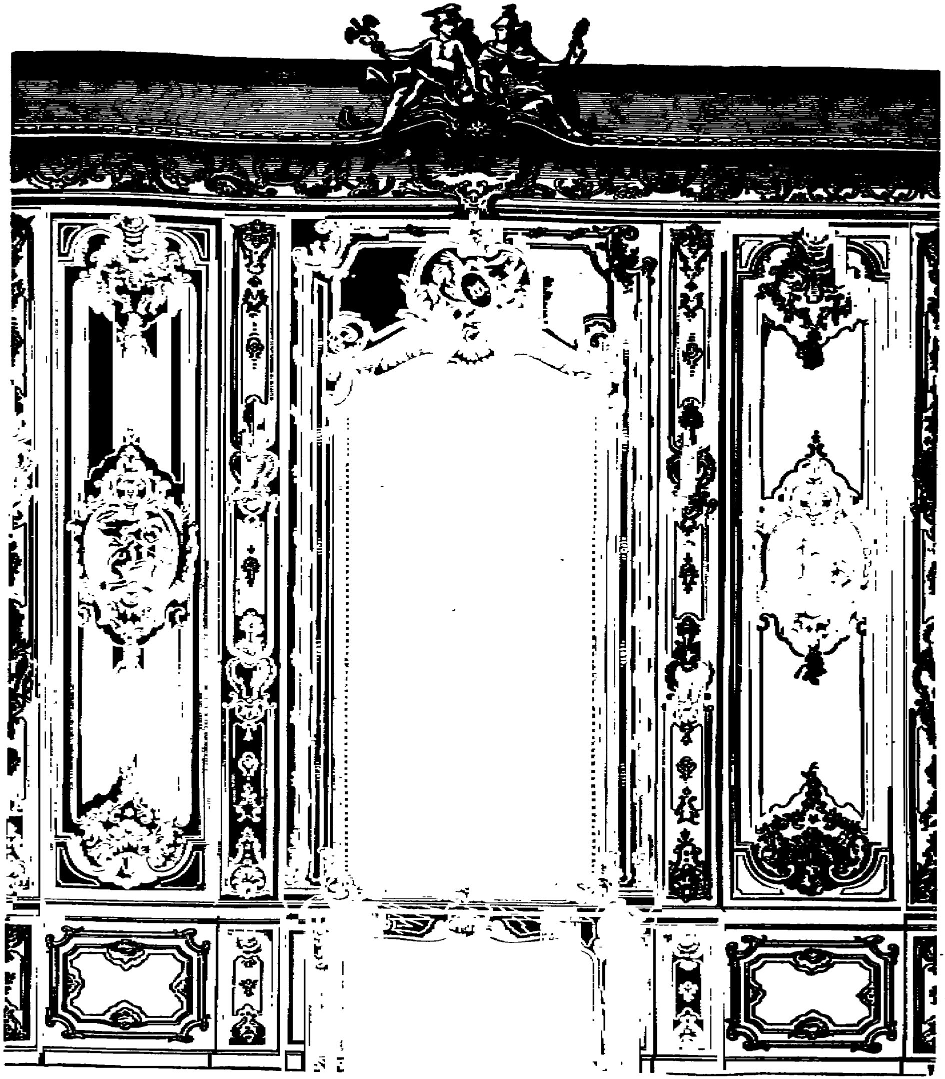


FIG. 1.

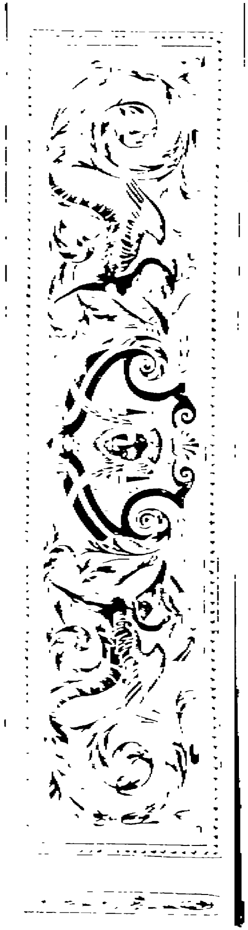


FIG. 4.

PLATE II.

PERSPECTIVE DIAGRAMS

FIGURE 1.

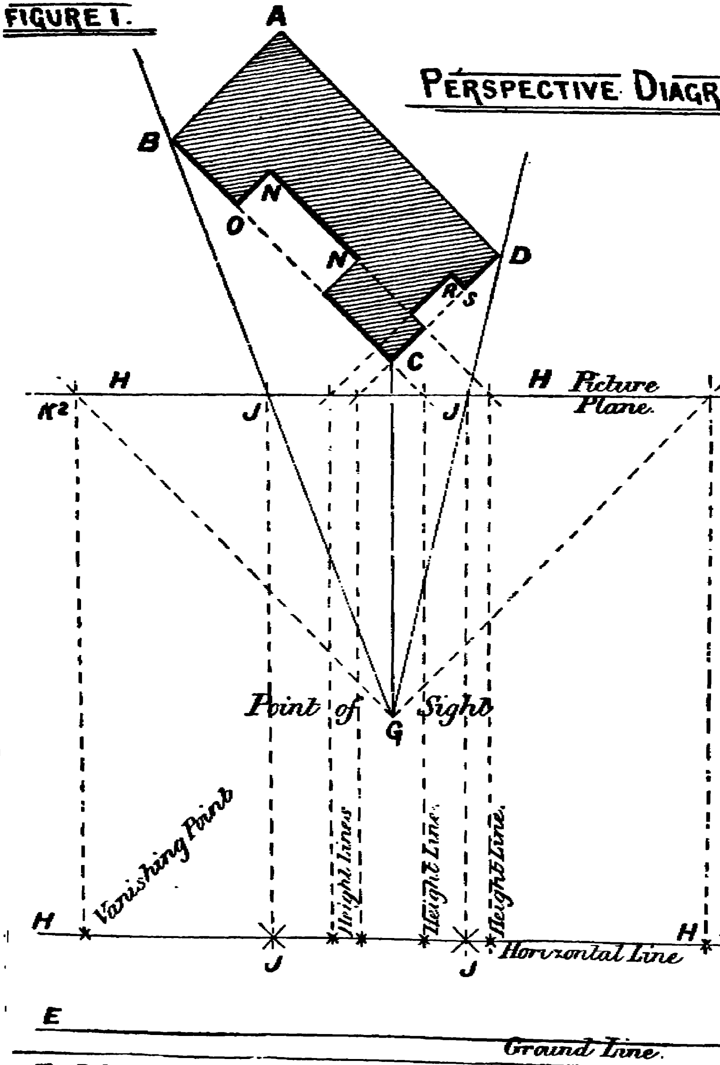
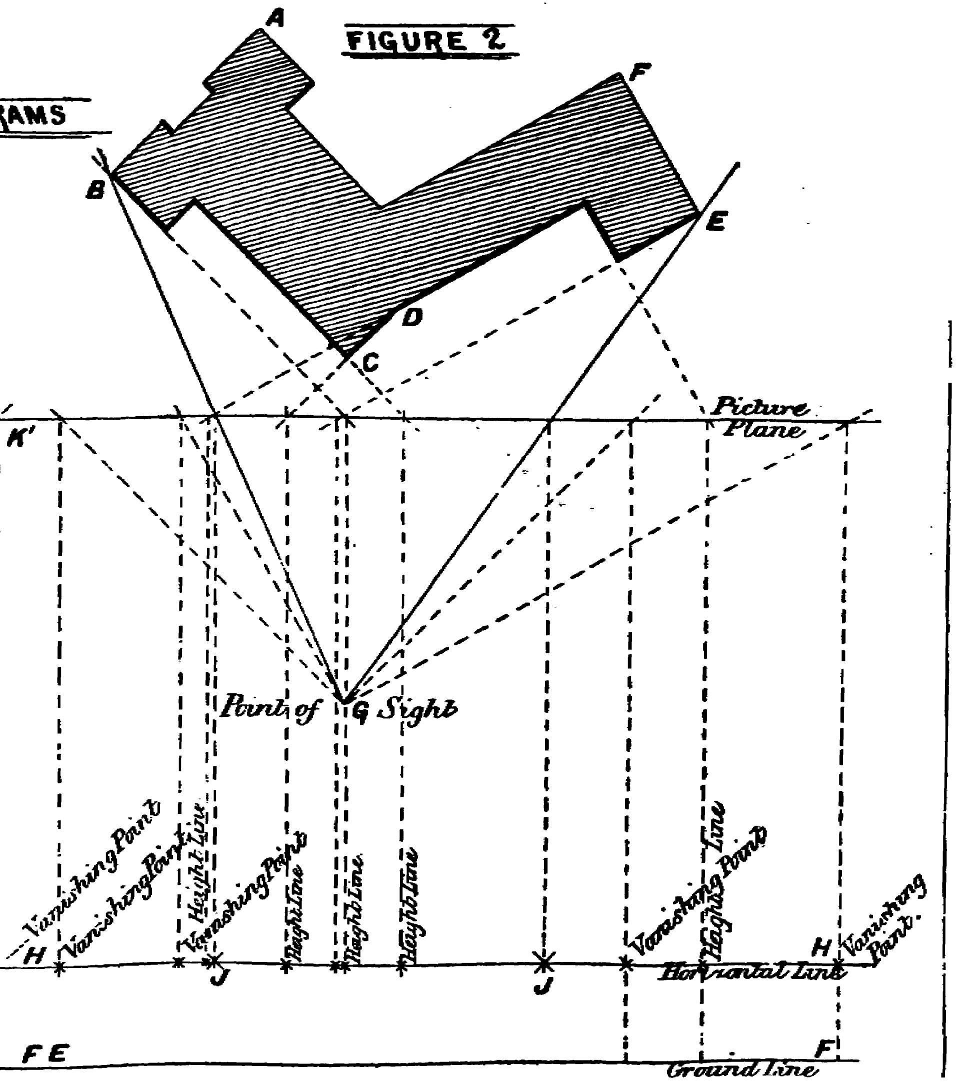


FIGURE 2



THE ORNAMENTAL DRAUGHTSMAN *(see Text).*

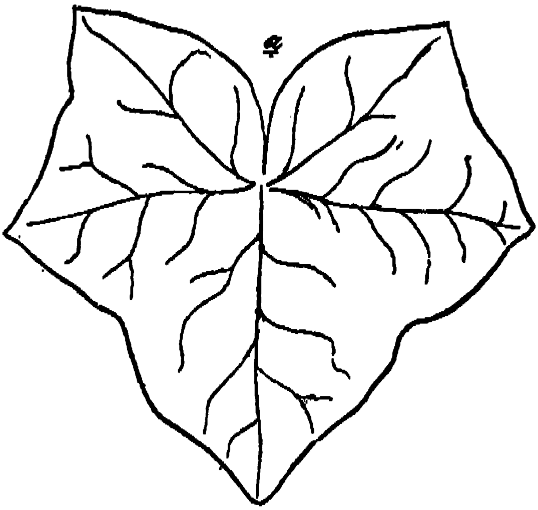


FIG. 1.

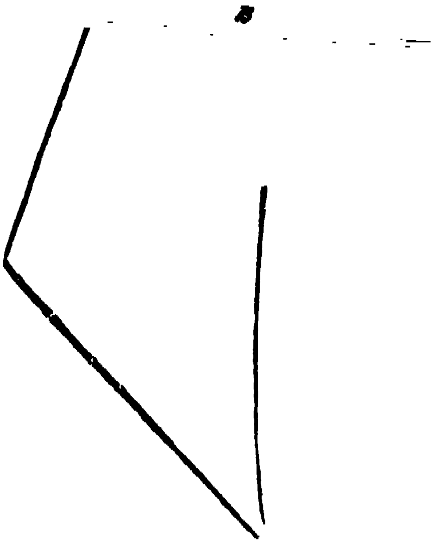


FIG. 2.

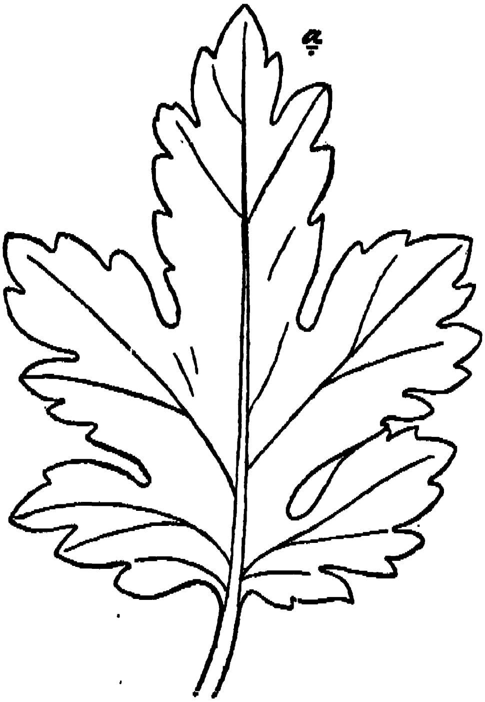


FIG. 3.

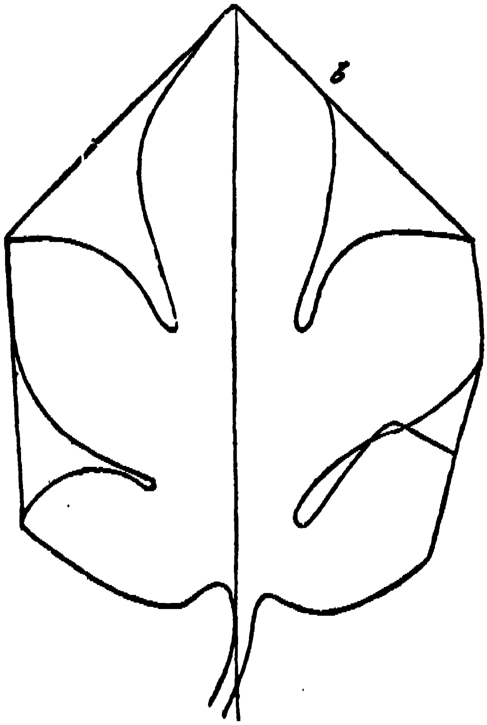


FIG. 4.

TECHNICAL EDUCATION

IN RELATION TO

THE PRESENT CONDITION OF OUR INDUSTRIAL WORK.

CONTENTS.

The Doing of Bad or Inferior Work—The Turning-out or Producing of Poor Materials or Inferior Goods—The Systematic Doing of Bad Work—The Production of Inferior Goods—The Doing of Cheap Work Systematically an Essentially Weak Point in our Position as Technical and Industrial Workers—Healthy Influence of Work done in the Best Way, upon Trade and Employment—Some Practical Development of the Vicious Principle of doing Bad and Cheap Work.

The Doing of Bad or Inferior Work—The Turning-out or Producing of Poor Materials or Inferior Goods.

But the full "power" which has given us our past, and which will retain to us our future supremacy as producers, will only be attained if to the determination to exercise it in the ways just named be added another power. This the very gravity of the struggle for work which we are maintaining with competitors all over the Continent is bringing more and more to the front as one of the important factors —if it be not, as some think it is, the most important factor —in those calculations which affect the future prosperity of our country. What this other "power" or influence is, and how it is to be brought into operation, we shall presently see. We have said that we are essentially practical in all our work—or, to use a graphic phrase, we are the "out-and-out best workers" in the world. We can do the very best work which workers can do, and we could always do it if we willed. Unfortunately we do not always will it. Hence, while it is quite true that we can do good work better than any other peoples—that is, truly and essentially good—it is no less true that we can do bad work. And, unfortunately for our highest and therefore our truest interest as producers for the markets of the world, we have not merely the ability to do bad work, but we do it on a most extensive scale. And the singularly suggestive circumstance is that so many amongst us have agreed to do bad work systematically. There is such a "purpose in this our madness" that we have positively educated ourselves so as to have the ability to do bad work in the best—that is, the worst way. This phrase, which will strike some readers as a curious one, has in reality a very close bearing upon this very point of "practicality" in work on which rests, as we have seen, our supremacy as producers. Only those who know what good work is, can form any conception of the difficulty of the task which is given to a truly good workman when he is asked to do bad work. We have known good workmen, the very kings of their calling, when asked to slur over their work—to do, in fact, bad work—frankly confess that they could not do it. Good work they must do—none other than this; they may charge less for it in the way of wages, but good work they will give, cannot in any wise do work other than good. Of course there are good and bad workmen in every branch; so that when bad work is to be done, the workmen who have "ability" or—not to use a good word in a bad sense—the "capability" in this direction, are found ready enough to hand.

The Systematic Doing of Bad Work—The Production of Inferior Goods.

But a further curiously suggestive point in the connection named in last paragraph is that the very practicality which we have seen to be the most valuable characteristic of the English workman crops out in the oddest of ways. So odd that it is absolutely true that we do bad work so systematically that we can make the boast—we can scarcely call it the proud boast—that we do our bad work in the very best of ways. We need not cite practical cases in proof of this paradoxical position; it will serve the purpose we have in view when we hint that the machinery or mechanism for doing bad work—let us say in connection with a certain branch of textile industry, is simply perfection in the way it does its work. Bad work is of two kinds. First, that which is done by a clumsy, badly-trained, or out-and-out inefficient workman. This is so transparent, so obviously and so hopelessly bad, that it deceives no one. Any one can see that it is bad; it makes no pretensions to be judged as good work. The second kind of bad work is of quite another class—its very intention is to deceive, to assume that it is good while it is nevertheless essentially bad. The greatest care is therefore taken that the deception shall be complete, and thus it comes about—as we have so paradoxically said—that the bad work is done in the best and most practical way. In *one sense*, therefore, it cannot be called bad work, for it is not badly, it is *per contra* beautifully done. But it is the beauty possessed by the apples of Sodom, the blossom of fine fruit externally, but dust and ashes within. Viewed in their moral aspects, the two classes of bad work come under two quite different categories. But of the bad work which is done in the best way there are also two classes. The work which is done with the intention to deceive is bad in every sense; but there is bad work, while yet done well, which is put out with no intention to deceive, but simply with the desire to give the best look to bad materials. Here the maker, pushed from one cause or another to do *cheap* work, confesses, or at least makes no effort to conceal the fact, that cheap work can only be—must be, because it *is* cheap—poor, that is, bad work. "You cannot get both good work and a low price; and if you insist upon having cheapness you get it at the expense of goodness." This is what in effect the maker of cheap and bad goods says.

The Doing of Cheap Work Systematically an Essentially Weak Point in our Position as Technical and Industrial Workers.

Now, it is the simple statement of a fact to say that it is difficult to overestimate the evil influence this desire either to have or to produce cheaply done work has exercised and still daily exercises upon the character of English production. It is here unnecessary to inquire whether the desire of the public to have or that of the maker to give to or force upon the public bad or cheap work is to blame for this. Sufficient, and unfortunately more than sufficient, it is to know that cheap work has done an infinite deal of mischief to our power and position as producers for the markets of the world. The very highest of our technical authorities have pointed out how the desire of purchasers to have cheap work—no matter what it be in quality, so that it be cheap—and the readiness with which some makers minister to this desire by supplying it, is literally sapping the foundations of our productive strength. They maintain—and facts to any extent are at hand to support them in their view—that this system is getting us and our work into such evil repute in markets where once we stood the highest, that those markets are being rapidly closed against us. Nor is the influence of this system upon the workpeople, those who produce the cheap and bad work, less to be deplored. No man can persistently do bad work, employing bad materials and knowing that he does so, without suffering a twofold injury. A material one, inasmuch as the doing of bad work in itself is the worst possible education for a workman. No matter what the class of work be in which he is employed, he has to unlearn much of what he has practised before he can begin to learn the doing of good work; and those accustomed to do bad work as a rule, have as a rule also but little desire to move in a higher walk and do good work. But the evil influence of the system is not less to be deplored when one considers how the *morale* of workmen engaged in it is lowered, till from the incapacity to do good work they sink to the yet lower level of thinking there is no evil in the doing of bad. Of the classes who maintain this deplorable system of cheaply and badly done work—the purchasers who must have it and those who produce it—it may well be difficult to decide which is the worst. We should be inclined to decide that the public, who insist upon having work done no matter how, so that it be cheaply done, are those who are chiefly to blame. For from one point of view it may be said that, so far as the producer of work is concerned, it is a matter of indifference to him whether he gives out bad work or good; in either case he is paid for it. But from the true point of view nevertheless the maker's best interest lies in the production of good work. There are very few indeed who are so lost to a sense of what is in itself the right thing to do, who would not "feel more comfortable"—to use a common but suggestive phrase—if they did good work, the very best of which they are capable, and would really be thankful to be spared what they know and feel to be, when things are called by their right names, a degradation. When a man has done work in the very best way possible to him, striving to his utmost to attain to it, he feels satisfied, and there is a mental and what may almost be called a physical, a material elevation of his being, as the result. This satisfaction cannot possibly arise from the doing of bad work. We hear on every side the complaints of the general public as to the difficulty there is to get workmen to do good honest work, worth the money they so grudgingly pay for it. It would be well if the general public, who groan over this what they call deplorable truth, would consider in how far they themselves are responsible for its existence. As a rule the public *will* have cheap things: whatever other attribute they may have, this of cheapness they must possess. The instances are very few and far between, indeed, when they insist that good, fair, honest work they must have, and when they avow themselves ready and willing to pay a good, fair, honest price for it. The position is, as a rule, quite the reverse of this. And recurring to what we have said above as to the moral injury done to workmen who are kept persistently at the doing of cheap work, it is difficult to see upon what grounds the general public base their fault-finding as to the difficulty of getting workmen to do good work. They have been and are daily doing their very best to place them in such a position that to meet their desire, or rather determination to have cheap work, the masters have been, so to say, compelled to educate—to train—their workmen in the doing continually of work which masters and men alike know to be bad. Bad in reality, bad in its moral influence, bad all round—everywhere and everywhen. As things are, the public keep working round in a vicious circle, which perpetually returns into itself, and towards the centre or vortex of which they compel or force all to be drawn.

Healthy Influence of Work done in the Best Way, upon Trade and Employment.

Time was when our technical and industrial work was done on wholly different lines—when masters and men alike held the highest views about work. They then prided themselves on doing only the very best work they could do; and the modern style of work and the modern class of those who do it, known now only but too widely and but too well by the names of "scamping" and of "scamps," were quite unknown. In those early times, the truly golden age of our working history, whenever and wherever English work was done or English productions were met with, the very fact that they were known to be English stamped them with the highest value. And this simply because the term "English or British made" was understood, and best of all believed, all the world over to be but a synonym for everything which constituted the highest value in the materials, and the best possible work of which human skill and knowledge was capable in its making or construction. We are far from saying that this has so completely changed that it does not apply at all to our present position as makers and producers. So far from this, we believe that it is just because there are many masters and men of the high class named above—the true aristocrats of British technical and industrial work—who still keep up the old reputation of English-done work,—more of this class than of the bad opposite,—that we to a large extent still maintain our supremacy as producers. Such men, with such work as they do, constitute in very truth the salt which prevents our going to utter decay. It was this grand principle of giving our very best work which formed the foundation and which raised the superstructure of that fame which placed English work and English produce at the highest point of reputation. It was this which created and maintained the world-wide markets, which brought customers from every quarter of the globe to our shores. But to this, which forms the brightest page of English technical and industrial history, there has been, as we have seen, a sad and a shameful reverse. That desire of so many—that "hasting" to be rich—has from very small beginnings reached to such a point of development that on the very largest and most extensive scale, manufacturers and tradespeople, in order to make a market, and above all to realize profits quickly, make deliberately and purposely goods of the poorest, and yet in such a way as to have all the external appearances of the highest quality. These have been sent, are being sent daily, to all parts, flooding markets with their debased products, to which markets formerly none but the very best products of English work were sent. At first this policy—for it was but this and nothing more, having not a shred of sound principle in it—succeeded. It took time for it to do its evil work; but it did not take long, and when at last "we were found out," such produce naturally and properly was objected to, and by many of our former customers refused to be had at any price. And to such an extent was this policy, suicidal in every sense, carried out, that in many markets—and unfortunately for our national interests, vastly too many—where in the better, the "brave days of old," "English made" was but an equivalent for everything that was good in material and sound in make or construction, the term became a synonym for all that was the reverse. Need it then be wondered at that other countries, competitors of our own in the world's markets, saw and carefully noted all this? They did see it, and were not slow to avail themselves of the opportunity which it afforded for them to gain what probably they never would have gained but for this our own silly stupidity, to give it no worse name—the commerce of what were at one time our markets and ours only. Our foreign competitors began, therefore, the making of goods for those very markets; and by giving honest, that is, good sound materials, and the very best of workmanship of which they were capable, they in some markets fairly ousted us from our former position. It is a matter of notoriety—so notorious that no one can, even if they have the hardihood, dispute it—that markets of which at one time we held the exclusive monopoly are now quite lost to us. It would at this period in our history be impossible to sum up the amount of work, and by consequence of money, which has been lost to us as a nation through this cause alone. If it were possible to arrive at some estimate of this loss, the mere amount of it would be so appallingly large that it would surely strike those who are even now doing their very best to perpetuate a system which has brought directly about such an enormous loss to the nation.

From a very early period in this pitiably sad part of English industrial history, the far-seeing, the prudent, and above all, the high-principled of our producers and workers, pointed out the suicidal nature of a policy like this, and warned their less scrupulous neighbours of the inevitable and disastrous result of it. But while wisdom thus cried in the streets she cried in vain, and matters proceeded from bad to worse till the bitter end was reached, and, as we have said, many markets once open were closed completely to our produce. But while, fortunately for us as a people, this wretched suicidal policy of grasping present profits at the expense of future work is the exception to that high-principled mode of doing business which should be the cherished birthright of all true Englishmen, still so widely is the influence of this evil policy extended, and so prejudicially does it now operate, that our high-principled technical authorities do not cease daily to raise their voice in earnest protest against it. They avail themselves of every opportunity to point out how the vital interests of the nation are bound up with a policy the very opposite, and how those interests can only be secured by doing everything in our power to get rid of the evil system, which is rotten to the core in principle, and ultimately ruinous if persisted in, to the practice of our future trade.

Some Practical Developments of the Vicious Principle of doing Bad and Cheap Work.

In an early paragraph we have said that it was not to one but to many causes or influences that we owed that supremacy in production which gave us at one time the absolute monopoly of the markets of the world; so will it now be seen that the influences at work which have caused us to lose much of that supremacy, and which have shut us out almost wholly from some, and to a large extent from a great number of markets, are also numerous and many-sided. But of these depressing causes there cannot be a shadow of a doubt in the minds of those who know intimately the actual facts and circumstances of modern practical, technical, and industrial work, that not the least powerful are the two we have been in the last few paragraphs considering. Namely, first the wide and strong demand for cheap work; and second, the production of altogether bad or deceptive work,—that which aims at finding a market for goods which profess to be what they are not. Of these two influences there are many developments, the directions of which, if it may not be difficult to trace, it is not easy to find space to specify or number. This, however, is not here necessary: it will suffice for the purpose we have in view to look at one or two developments of these essentially hurtful and vicious modes of doing technical and industrial work, from which one may judge of the whole.

We have said the direct tendency of what may be called the "cheapening system" is deterioration. Of course it is not meant by this term that it merely or only lessens the value of the article produced or object made in those particular instances in which cheap work is done. That result is an obvious and a necessary one. But by the term used is meant this: that the cheapening system is essentially one of deterioration, inasmuch as the more it is practised the more lessened is the power to do good work even when that is required, and when it may be willingly enough paid for. One cannot continue an inherently bad course without becoming, the longer it is followed, all the less able to take to a good one, or having taken to it, to follow it on and up. It is the essential vice of all degrading work that the longer it is pursued the more degraded become those working at it. This, in fact, constitutes its severest punishment. It may therefore be reasonably anticipated that the punishment of the future for our persisting in the vicious cheapening system will be more severe than it has been up to and at the present time. And how severe that has been in lowering that "power" which enables us best to meet the keen foreign competition we have now every day to face, those best know who have a practical and an intimate acquaintance with the facts and circumstances of our national technical and industrial work. As illustrating in a practical way the evil effect of the vicious systems of production we have been considering, let us suppose two cases, which have, however, but too many parallels in the daily practice of traders, carried on amongst us.

A large contract for works required by a public department is announced, and estimates or offers invited. The amount involved is so large, and the work of that character, that the largest and wealthiest of our firms enter the competition in the hope to secure the work—all the more necessary to be obtained as that condition but too well known in this country as "bad times" may be presumed to exist. It need scarcely be said that the estimates of these high-class firms are based throughout on this principle—that the best of materials are proposed to be used, the best of work determined to be given. In brief, they are honest offers to do honest work, in the hope of deriving such profits as may accrue from it, but such only as may be legitimately expected. But it remains to be said—what can easily be understood—that those honestly-drawn-up offers, with an honourable intention to fulfil them, have to be placed in contrast with offers from other firms. What honourable standing in the true sense of the term those other firms have, may be guessed at from the statement that some of those "offers" are for amounts which could not possibly pay—for sums which could not possibly give, not merely good materials and sound workmanship, but materials moderately good and workmanship even of a second-rate character. In brief, those low estimates or offers are apparently framed without any consideration of what is the real character of the work required. Competition of this kind it is obviously impossible for any honestly conducted firm to meet or face. In place, however, of simply and at once retiring from the field—in view merely of the large sums as well as the value of the principle involved in the matter—it may be deemed right that some representation should be made concerning it in official quarters. The mere position of the members of the firms may ensure what is not always easily obtained—an official hearing. It does not concern us to assume either that the result is favourable, or that things are permitted to take the course but too frequently followed—that is, to allow the question of price alone to determine the matter, this being in favour of that offer which is the or amongst the lowest. In all cases where low offers or estimates decide the question on which work is to be given out, it may well be asked what chance have firms who only give good or the best of work with those who cannot possibly have any regard to the honesty of the work they propose to do, if that is to be measured by the price which they ask for it? If well-conducted firms are to obtain work at all under such circumstances, what resource can be left them but simply to follow in the same evil course, and be perfectly indifferent as to the character of the work done, so only that it can be cheaply done and have a profit somehow or other screwed out of it?

It is not always easy, in many cases it is impossible, to divine or fathom the motives which induce parties competing for work to send in offers the amount of which cannot possibly allow either good materials to be used or good workmanship to be given. But some of our readers—those who are youthful, at all events—will be somewhat surprised to learn that instances are not quite unknown—seriously they are but too frequently known—in which the parties competing, and who have sent in "offers" of the lowest kind, altogether incompatible with work having even an approach to moderately or passably good—have been not on the verge of bankruptcy, but at the time actual bankrupts. With such, and others but too like them, the only object is to get work, no matter how; and getting it, to do it in the best fashion possible under the circumstances—which fashion may, even by inexperienced readers, be guessed at. What influence this style of doing business has on the character of work, but more especially on the character of those engaged in doing it, may be guessed at. But if we further consider that work of this class goes to foreign countries, their governments, or to private consignees abroad, one can easily understand what the influence will be on the actual prospects of our trade. If such foreign peoples have not already begun to compete with us in work of the kind, the loss and disappointment arising from the bad work they have got from us will add another to the many strong reasons they in common with other foreign peoples always have to enter into competition with us, and to do their own work for themselves. Or if already in some way competing, the influence of this unfortunate experience of our bad work will be such as to make them earnest to make their competition all the more powerful than before. And thus it may come about that, in place of doing their own work only, they may do it so well as to take up a wider field of competition with us, and supply peoples other than our own whom we have at one time supplied· Such, in point of fact, is the actual phase through which more than one competing nation has entered the field with us to our own great loss and detriment. Looking at the matter from a common-sense point of view, this would appear to be the wise and worldly-prudent thing for us to do: namely, to give such good work to foreign customers that they, being thoroughly satisfied with it, will have no desire to do it for themselves, feeling that they could not be better served than by coming to us. What is the result of the opposite course we unfortunately in too many cases know but too well.

We now suppose another practical illustration, showing the evil developments of the evil principles we have been considering, which also has its parallels but too frequently in practice. There are in this country certain very important branches of technical work carried on, which require certain materials of a more or less costly kind. The making of those materials gives rise to another and correspondent class of work, involving as a rule not merely the application of principles of the highest scientific value, but extreme care in manipulation and general treatment of the substances. Our best establishments, whose interests are to do the best of work, use naturally the best of these materials. Now here comes the point. Let us suppose the following, as for example, (1) That the best materials are procured from abroad, the Continental makers excelling ours. So much so that our makers cannot, at least as a rule do not, offer samples or sell in bulk materials of the same quality. That what as a rule is offered for sale by our makers is not to be relied upon as possessing the same purity and value as that offered by their foreign competitors, or if it be as good at one time, is not so at another. (2) That the foreign makers, on the contrary, offer what is almost always in the state of purity it claims to be; and where quality varies, the variation is plainly pointed out by the seller, and the price is in proportion to the purity or quality. (3) And that to adulterate or to be careless in the production of the materials has as yet, at all events, not been thought of by many foreign makers: on the contrary, that they make every effort to improve the manufacture and to economise production; and where that economy is secured and the cost of production lowered, the English purchaser is always made to participate in the benefit by being asked a lower price. And suppose further, (4) that the foreign maker is not seldom known to devote his labours to the making of one product only, giving his best energies to the perfecting of the process of making it, aiming not so much at making large quantities of it as at making what he does of the very best quality,—and if as the natural result of all this he increases his trade, and by this means his capital, he often devotes a large part of that to the improvement of his trade. Suppose that all this constitute existing facts,—some of our readers connected with certain trades will know very practically, and possibly painfully, whether they be so or not,—and that such at least at present is the state of the trade carried on by the foreign or Continental makers of the materials in question, and which are as a rule preferred by *our* best or high-class manufacturers or traders who use them in their business. The reader will naturally say that this method of doing business is sure to be successful, for it is the best way. And they—at least some of the less experienced of them in the ways of trade—will be disposed at once to conclude that this best way is also that followed by at least the majority of English makers of the same materials. Let us finally suppose that this is *not* so. Surprise, in that case, will not be expressed at the fact that some, if not all, of our English makers should complain bitterly that they are not able to compete with the foreign makers, who therefore take the best of the trade. Some of our readers will conclude that the true ground of surprise would be if, under the circumstances named, our English makers expected with their system the result to be different. Doing business in the way we have been *supposing* they do, it would be a true surprise if they *could* compete with their foreign rivals. Not merely in the particular case cited, but in other departments of manufacture of substances used in trade, it is too frequently the case with us that, however careful makers are in the early stages of their business to make their materials good so as to get a reputation for them—when once that reputation is made and the business pays, they relax their efforts. They get careless as to the high quality of their products, contenting themselves with the reputation they formerly gained. It would be well for our trade interests if, in such cases, carelessness in the original method of making were the only result. Too frequently adulteration is resorted to, in order to increase profits. This adulteration, indeed, is with some in the trade practised from the very first. And in connection with at least one branch of work cited above, it is a curious thing to note that some users do not complain of the materials being adulterated,—what they do complain of is the deceit practised, the "trick played" or attempted to be played upon them, in passing off materials for what they are not. And here it is worthy of note that it seems to be the very irony of fate that some English tradesmen should so bitterly complain of the deceit of a system which was inaugurated by their own countrymen, and which so many of them have played off upon foreign customers.

THE JOINER:

THE GENERAL PRINCIPLES AND THE DETAILS OF HIS WORK.

CHAPTER I.

Introduction.

THE material with which the joiner works, like that of the carpenter, is timber or wood. These terms are scarcely synonymous. Taken as separate or individual names, they in some measure indicate the difference which exists practically between the two classes of work, that of the carpenter and that of the joiner. When the term wood is used generally, it is intended to convey the idea of the kind or class of material obtained from trees, large or small as the case may be, and which as a constructive material is known to possess qualities very different from the other constructive materials known as stone or iron. But when we come to use the generic term wood, as applied to some definite kind of construction, we find that it assumes two branches, to one of which the term "wood" is still applied, to the other the term "timber." And it may be safely held that even in popular estimation the term "timber" or "timbers" conveys the idea of the material present in large masses, to which the names of "balks," "logs" or "beams" are applied (see the "Cyclopædic Dictionary of Technical and Trade Terms"); and the trade concerned in the working up of which is also popularly understood to be that of the carpenter. On the other hand, still keeping the distinct trade in view, when we talk of the generic name for the material as being used, we give the term "wood" or "woods," and conceive of its use in connection with the work of the joiner. And joiner's work, we all know, deals with the material in comparatively and actually small masses or pieces; the work done with these giving a very wide array of names.

The Distinction practically made between Carpenter's and Joiner's Work.

The distinction above glanced at in practice constitutes the difference between the work of the carpenter and the joiner. The carpenter deals with the material in the form of long and bulky pieces, and out of them arranges certain large structures, forming the joints and piecing or placing them together, in order to make —keeping in view house building or construction only —the floors, partitions and roofs. These may in one sense be called the external work of the structure, but more correctly the general framework by which the walls are, so to say, bound together, and by which the whole is covered to protect it from the inclemency of the weather. In this class of work the timber is left with its surface rough, just as it comes to the hand of the workman from the saw mill, or as it is imported direct from the "lumber" works of the forests of northern Europe, in the Old World, or from those of America in the New, from which our supplies of timber are obtained. And while referring to the term "forest," it is curious and suggestive to note that the distinction between "timbers" and "woods" in relation to size which we have observed is carried out more or less in the case of the places where timber is grown. Thus we know pretty well generally that when we talk of "woods" we refer to tracts of land under timber comparatively limited in extent, and bearing trees not very large or very old; when we use the term "forests" we mean more extensive tracts, including very large and very old trees, and very numerous.

General Character of the Work of the Joiner.

Leaving the specific work of the carpenter (see "The Carpenter"), on the other hand we find that the joiner takes the material in pieces of comparatively small size or bulk, and cuts them into the form or shape and the dimensions necessary for certain "fittings" of the house—the surfaces in all cases being made clean and smooth; this being generally done by the operation of "planing." The "fittings" of a house in wood, or "joiner's work" as it is generally termed, come under two classes—exterior and interior work. The exterior work comprises the external, front, back, or street doors—the window frames, and where stone work is imitated in wood; bay and bow window work, eaves, cornices, barge boards, etc., etc. The interior work comprises the floor proper, or the surfaces on which we tread, known as "flooring boards," the finishing of these at the parts where they join or come up to the walls, known as "skirting boards," "dados," and the like; the interior furnishings of the windows, as in sill, architrave, shutters and shutter-boxes, interior doors with their architraves, and panelled work. Chimneypieces formerly constituted an important part of the work of the joiner. But wooden constructions are now almost wholly superseded by stone, marble, enamelled slate, and for bed and less important rooms cast-iron chimneypieces. A very important part of the work of the joiner is the design and making of the wooden staircases by which communication is had from one floor to the other—and in connection with this the department of hand-railing. The class of work done in those two departments—staircasing and hand-railing—is in many cases so difficult, and involves, especially in the case of hand-railing, so many intricate problems, that they are frequently pursued as a distinct trade. The various inside fittings of a house, such as shelving, etc., all come under the domain of the joiner, who also undertakes all the iron work connected with doors and windows, etc., etc., and which—as hinges, latches, locks, etc., etc.—are known generally as "furniture," such as door furniture, window furniture.

Brief Historical Glance at the Art of the Joiner—Its Technical Suggestions.

In considering the relative antiquity of the two trades, the carpenter and the joiner—although the two are frequently combined in one individual—there is no doubt that the palm of seniority must be awarded to the trade of the carpenter. Shelter was a primary necessity (see the series of papers entitled "The Carpenter," and that of "The Stone Mason" and "The Bricklayer"). And this, as we have seen from those papers, would at first, and for long, be of the roughest and rudest kind. But as the arts of civilisation multiplied, the demands for mere shelter from the inclemency of the weather would be supplemented by those which a desire for something more than shelter—namely, that for comfort—would evoke. And as wealth increased those internal fittings, which at first would be of the simplest kind, would be made more luxurious, and both in general form and in detail would begin to minister to that taste for the beautiful which seems to come with increase of comfort and of luxury. We can easily conceive, then, that at first, as the interior fittings would be rough and heavy, and the conveniences clumsy, the carpenter who had framed the timber work of the house would take in hand the making of those fittings. And it would only be at a later period, when the fittings became of a lighter character and more ornate in design, and consequently more difficult in construction, that finer and more costly tools would be required than those in use by the carpenter, and in keeping with the tendency to promote division of labour, which naturally brings with it an acquirement of greater skill, and which was early developed in the progress of civilisation and its varied arts, the making of the interior fittings of houses would become a distinct branch, and the special trade of *"the joiner" would become established.*

Subjects to be Treated of in the Present Paper.

In the present series of papers we intend to explain and illustrate not so much the tools and appliances with which the joiner works—as those can only best be understood when seen, handled, and worked with, or seen as worked by the hands of a skilful workman—as his actual constructions and their details. Nor will this be here necessary, as it is intended to devote a series of papers to the special subject of "Handicraft Tools." Our illustrations will, therefore, have reference more to the form which certain parts assume, or their design, than to the way in which they are made by tools,—more as to *what* is made or done at the bench than *how* it is made. This latter part of the joiner's duty can only be learned thoroughly by working at the bench, seeing how the work is done, and by long continued practice in the doing of it. This plan or mode of treatment does not preclude us, however, from giving sundry hints incidentally, or more systematically as occasion serves, as to how work should be done. As to which point all that is at present essential to say is that the work should be honest work—the very best which the workman can give; no shirking, or "scamping"—as the graphic phrase of the workshop puts it—being at all admissible. If the very best which the young joiner can give be not the best which is wanted, that best will come in due course in virtue of practice and a dogged determination to succeed. "Rome was not built in a day," and finished workmanship is only reached by patient and honest practice. Some may reach it quicker than others, for abilities vary with different men. But although the progress be slow, still if improvement be clearly made, the young workman must not and need not be discouraged: quickness will come with practice, and good work also—the one thing required in all cases being a determination to do one's very best.

Classification of Joints.

The first department which shall engage our attention will be that of methods of joining pieces of timber together which are placed or lie when joined in certain special relations to each other. This department is technically termed "joints," and bears the same relation to the finished or completed parts as the "joints" illustrated under the title of "The Carpenter" bear to the finished constructions—as floors, partitions, and roofs—which see. Of the joints used in the joiner's art it is not easy to give a precise classification in definite groups or families. This does not arise so much from their mere number—although this, as will be seen, is great; but because several, so to say, overlap each other, and are dependent upon or are related more or less closely to some other. Some again so overlap with, or in principle so closely resemble, similar joints in carpentry, that it is not *easy to separate the two by any distinct line of* demarcation. In the present work this will not practically much concern us; inasmuch as both arts—that of the joiner and that of the carpenter—will be found treated of in its pages. A classification of the joints used by the joiner into groups sufficiently precise to enable easy reference to be made, so as to become acquainted with their characteristics, may, however, notwithstanding what has been said above, be made, and will be here attempted. We begin with the joints used in joining two or more pieces, each comparatively narrow, and of equal, or it may be of unequal, breadths or widths, in order to form a flat surface, such as a simple door. (See a succeeding chapter on the different forms of doors in use.) When the separate pieces joined together are placed in their permanent position, in which they are subjected to certain strains tending to separate them, after they are joined individually, or rather after two or more contiguous pieces are joined, they are collectively held together as one piece by certain methods which again may come under another classification or group of joints.

Joining of Boards together to form a Broad Surface.—"True" or Perfectly Flat and Square Edges in Joined Boards.

This is one of the cases alluded to above, in which two groups overlap each other, so to say, or are used in conjunction. In the group in question, the primary idea of the joint is to place two contiguous boards in relation to each other, so that their edges shall touch one another throughout the whole length, the joined piece, or "board" as it is technically termed, forming a flat surface, of which the breadth is equal to the sum of the two separate pieces. The simplest of all the joints in this group is obviously formed by preparing the edges of each separate board in such a way that the surface of each edge shall be perfectly straight—or "level," as some would call it—from end to end, and that moreover each edge shall in relation to its breadth or width—that is, the thickness of the board or plank—be at right angles to its faces or flat surfaces, and that at any part of its length wherever tested by the "square." An edge thus formed—the tool called the "plane" being used to produce it—is called a "true," or a "perfectly true," edge; and when two such edges are brought in contact, as at *a* and *b* in fig. 1, the joint is said to be a "true joint."

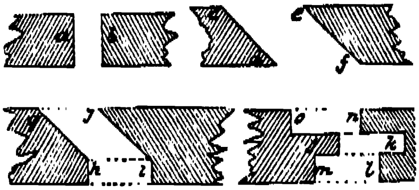


Fig. 1.

In some cases, as where a joint pretty fairly air- or water-tight is required, or for other reasons, the edges, in place of being at right angles to each other as at *a* and *b*, are made to slope, or are "bevelled" or "splayed" off, as at *c d* and *e f*. Those when joined or placed together give a less direct course, so to say, from one surface to the other, or to the line of joint. So also in the forms of joint at *g h*, *i j*, in the same figure. In this case, as in the joint at *a b*, the edges *g h* and *e f* must be perfectly "true"; the angle being once decided upon, and the "bevel square" set to that angle, the face must be true to that at any and at all points in the whole length of the joint. If this be not secured, as also in the case at *a b*, the joint will not be "true," and the two pieces will not be square or flat, but will "ride" or jog or jolt when moved. Absolute "truth" is requisite in all joints.

Joining of Narrow Boards together Edge to Edge to form Broad Surfaces.

It is obvious that, however accurately the edges at *a b*, *c d*, in fig. 1, may be made, the two pieces when put together will be separated with extreme ease. In rough work nails may be driven in diagonally at each end, and at various parts of the length of joint. But in superior work, where joints technically termed "fair" are required, methods other than this rough, if ready, mode of keeping the boards together are adopted. In fig. 2, the joint used when boards are "tongued and grooved" is illustrated. After the edges, as *a* and *b* in fig. 1, are planed or made "true," a recessed part, technically called the "groove," is "ploughed" out by a plane used for this purpose, along the centre of the edge, shown at *i j*, fig. 2, the full length of the board; this is shown in section at *c* and *d* on the edges of the two boards *a* and *b*. The two boards thus grooved on their edges are brought up edge to edge, and a long, narrow and thin strip, technically called the "tongue," but considered as a separate piece frequently termed a "feather," is driven in tight, as shown at *g*. Or the one half of this—shown in section at *h*—may be driven in the groove of one piece, *f*, and when in place the groove of the other piece, *e*, may be passed over the projecting part of feather or "tongue," and then "driven home," as the technical phrase has it. The tongue or feather *g* or *h*, while fitting the space formed by the two grooves, when the pieces *a* and *b* are brought together, as at *e f*, must not fit too tightly, as when "driven home" it is apt to split the sides of the groove. Another method of joining boards together edge to edge is shown in fig. 1, at *j k l m n o*, in which the projecting part at *j*, or tongue, enters the groove *k*, the edges *l* and *m*, *n* and *o*, butting or lying against each other. This forms a secure and an air- and water-tight joint; and many modifications of its principle will be met with in the illustrations yet to be given.

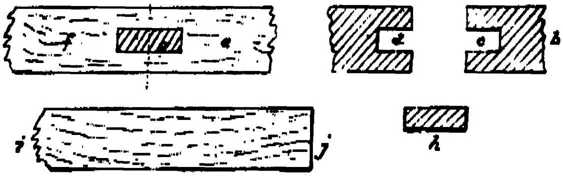


Fig. 2.

Joining of Boards with Ribs—Precautions to be taken in Nailing on the Ribs to the Boards.

A very simple method of joining boards or planks together, edge to edge, is shown in fig. 3; the two boards *a* and *b* are brought up edge to edge at *c*, and the joint covered with a "slat," "batten," "rib," "firring-piece," or "bar," *d*, or "roll," *m*, broad enough to pass some distance beyond the joint on each side of it. This method is generally adopted in the construction of superior sheds and timber houses. In work of this kind, as the boards *a* and *b* shrink laterally, tending to separate from each other in the direction of the arrows *e* and *f*, widening the joint at *c*, great care must be taken to nail one rib or feather, *d*, to *one only* of the boards, either *a* or *b*. If nailed to both boards, a rupture either of the rib *d*, or the edge of one of the boards or the edges of both pieces, will be almost sure to take place, giving ugly splits, and destroying the integrity of the connection as a good air- and water-tight joint. This splitting of the wood is caused by the great power of shrinkage of the boards *a* and *b*, and which being, as it were, encountered or resisted by the rib *d*, preventing them separating, the shrinkage force is greater than the tenacity of the small part of the edges of which the nails take a hold, so that part gives way. But when one rib *d* is nailed to one of the boards, as *b* only, as we have shown is the rule in sound work; when the shrinkage takes place, the board *b* is free to move away from the board *a* with its nailed rib *d*, so that no strain is thrown upon the board *a* and rib *d*. When a shrinkage ceases, and swelling of the boards takes place, as in damp weather, the boards meet again at the edges *c*. To allow of the boards giving and taking a little in case of damp weather, the joint *c* should have a little "play" given to it—that is, the boards *a* and *b* should not be allowed to be pressed up very closely together when the rib *d* is nailed to one of them. When the ribs, as *g*, are fastened by two nails, as shown in fig. 3, the action of the expansion of the two boards, in tending to split the wood, is represented by the arrows *e* and *f*. In fitting up boards in this way, the "joiner" will have to exercise his judgment, dependent upon the condition of the boards and the state of the weather at the time of fitting them up. Allowance will have to be made when the boards are damp or ill-seasoned, or *vice versâ*. The elevation is shown between, at *j j*; the ribs, as *d*, are in superior work splayed or chamfered, as at *k k* or *l*, or made half round, as at *m n*.

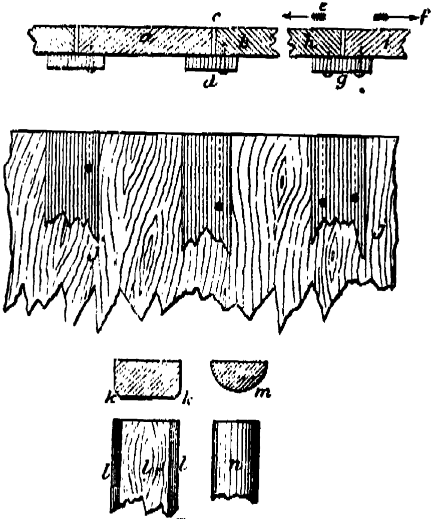


Fig. 3.

Joining of Boards Edge to Edge by Sunk Feathers or Ribs—Rebated Edges.

Another method of joining and securing boards together is illustrated in fig. 4. In this each board is either worked or tooled by hand, planed or cut by a machine, so as to leave the edges formed as at *e* and *f*. This form of edge is technically called a "rebate." When two boards are placed edge to edge together, spaces are formed between them, running along the whole length of the boards. Into those spaces, tongues, fillets, feathers, or slats, of section as at *h* in fig. 2, of dimensions a trifle less than the size of space, are passed into it, and secured by nails which may be driven in at the back—the nails, as in the case of the method at *a b*, being driven in at one board only. The "fillets" are shown in place at *g* and *h* in cross-section, and at *i* and *j* in front elevation.

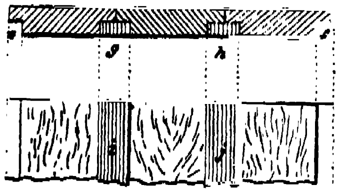


Fig. 4.

Joining of Boards—Quirk Moulds, tongued and grooved, and with Quirk Bead.

A modification of the method shown at *j k l m n o* in fig. 1 (*ante*) is illustrated in fig. 5, as at *a b* in elevation, and as at *a′ b′*, *a″ b″* in section; the boards being alternately tongued and grooved as at *a′* and *d′*. The edge on the face of the boards or planks *a* and *b* is finished with a moulding known as the "quirk" moulding, as shown at *b′*; the other face may have only plain joints, or the edges of both boards may be provided with quirked mouldings, as in the drawing.

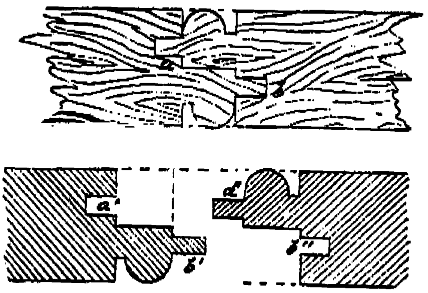


Fig. 5.

THE BRICKLAYER OR BRICKSETTER.

THE PRINCIPLES AND PRACTICAL DETAILS OF HIS WORK.

CHAPTER I.

Introductory.

It is not necessary to inquire into the relative claims to superior antiquity of the sister arts of building in stone and brick. Unnecessary, in any practical sense; for as regards the history of both, their origin is so shrouded in the mists of time, we have to go back to ages so remote, "hoary gray with eld," that all that is left us is but crude conjectural notions of the vaguest and most uncertain. Examples of construction both in stone and brick are met with in various parts of the globe, the times of which are so remote that the very names of the peoples who built them are almost, in some cases wholly, lost. And of both materials, stone and brick, examples of construction are met with, the work of peoples who flourished so long ago that they formed the very earliest nations, who had become so civilised that they practised various arts, and that in so marked a style of excellence that we moderns have nothing left but to admire and wonder at their work; so far are any examples of ours from approaching the standard they had reached. It is always interesting, and not seldom is it fraught with lessons of practical value, to inquire as closely as may be open to us into the early history of the practical arts, and to trace, if possible, the successive steps by which they have reached the position of practical efficiency, if not of absolute perfection—if this last condition be indeed an attribute of any work to which man puts his hand, and to the designing of which he puts forth the best and highest of his mental powers. Whereas in tracing the origin of arts such as those of building in stone and brick of such remote antiquity, conjecture is only left us; and one conjecture may be taken as of equal value with another, in so far that both at least may be not only possible, but reasonable. In this way, so far as regards the relative claims to antiquity of the arts here referred to, we may hazard the conjecture that of the two brick building was the first to be practised. In the very earliest times, as the poet sings, "wild in the woods the naked savage ran," and the first advance from this wretched condition towards providing himself with shelter would be either hiding himself in the ready-formed caves and holes of the earth, sheltering himself under the shade of recumbent and superincumbent rocks, or raising rude huts of tree-trunks and of branches. (See the paper entitled "The Carpenter.") But in regions where wood was absent, and the diversified surface of hill and dale and rocky pass and glen of other countries was represented, as in many parts of the East, by vast plains the soils of which varied from loose and shifting sand to clay or clayey earth of greater or less consistency,—here, where the sun beat fiercely down, and was but rarely obscured by cloud or mist, mere shelter would be a far less important consideration than in the colder and bleaker regions of the West and of the North. Even now, in the sunny lands of the East, the tent gives all the shelter that is needed, and failing that, as in wandering from place to place, where to plant the tent involves labour, which in that lazy land is too often grudged, the "shadow of a great rock" suffices. Man from the earliest times has ever been, as some have defined him to be, a war-loving animal, and whether indulging it from pure love of its exciting dangers, or from a desire to take from his neighbours what he himself does not possess, or possessing, desires to add to, man has from earliest times given almost the first place to war and the arts of war. Mere bodily shelter in those warm climates being but, as we have seen, a purely secondary consideration, what structures at first were built or heaped together would have more for aim shelter and security against predatory foes or warlike neighbours. In those early times, when existed widely

> "The good old plan,
> That those should take who had the power,
> That those should keep who can,"

there would be on the part of those who had taken an endeavour to keep what they had acquired. So that structures such as they were would have for their object not so much merely personal shelter as storehouses for "ill gotten gains," which otherwise could not be defended against those who had the same desire to take what they could.

Brief Glance at Early Brickmaking and Building—Practical Lessons to be derived from it.

In the regions which formed the "first cradle of man" wide plains exist, and in some instances of vast extent, in some parts of which even the shadow of a great rock cannot be obtained. For purposes of defence, then, the most obvious of all means would be the mound and the trench. "Earthworks"—which, in the curious changes which come about in the world's history, form now an important department of the art of war—would then be the prominent feature of construction, either for shelter or defence, of the earliest times in such lands of the East as we have alluded to. Where the soil was sandy, such earthworks, while made with the greatest ease, would, however, be of the least service in the way of defence, nor could any great height be obtained in the sheltering mounds. But where, as in the plains on which the vast hills—for they are literally so—made up of the remains of the once grand and gigantic city of Nineveh presented for so long a period a perfect puzzle to the traveller, alluvial soil of a more or less tenacious character was met with, the mounds and trenches made in the first or earliest efforts at construction would be of a much more effective character as regards strength and size sufficient to resist attack. In the throwing up of mounds and the consequently following digging of trenches with a direct object in view, lumps or masses of soil bound or concreted, so to say, together would often be met with. The value of these lumps or masses, when used in conjunction with smaller pieces or more disintegrated material, in forming a mound, would not remain long unperceived. For men in almost every—except possibly the lowest—state of existence are inventive; some are specially and cleverly constructive animals. The use of such lumps, when carefully assorted, would soon lead to the obtaining of a structure presenting some at least of the characteristics of what we call a wall. Nor, seeing the advantages of having the soil in masses, would it be long before man would perceive that, in place of trusting to chance in obtaining such lumps or masses capable in some fashion of being built so as to form a mass of a certain and a predetermined shape and extent—such chance as his rude spade and mattock would give him in digging the trench for the raising of the mound—it would be a good thing if he could make those masses himself. Very little inventive knowledge would be required at first to show how the tenacious character of the soil could be taken advantage of in forming masses suitable for his purpose, this work being greatly aided by the use of water. In process of time the great constructive advantages of having masses of definite size would be perceived. Further, that a wall—for that would be the ultimate form of the defensive shelter-place—boundary, giving *enclosed* spaces, could be built not only more quickly, but much more strongly, if those masses made, literally and truly *manu*factured (see "The Dictionary of Technical and Trade Terms"), by pressing soil together either in its natural condition if moist enough, or by the help of water if too dry, were of small or comparatively small bulk or weight. For in time men would perceive that many small pieces or masses would bind together better than fewer and larger pieces; and hence the first conception of the truly great constructive discovery of the principle of "bond" might be obtained. And it would, as a further step in constructive invention, be next discovered that this binding together or "bond" of the separate masses would be better secured, and a stronger wall would be obtained, if the dimensions of each mass bore a certain proportion to each other, as length to breadth and both to thickness.

At first, in all probability, the successive layers—or "courses," as in modern brickwork they are termed—thus formed of small masses or pieces, would be made to cohere together or pressed into a mass to give stability and permanence, by using the pieces while they were soft and capable of being pressed or squeezed together. We have as little knowledge of how "mortar" was discovered, and its vast advantages in construction began to be availed of, as we have of the origin of the arts of masonry or of brickwork; that it was first used in stone construction is exceedingly probable,—just as it is most likely that what led to the drying of the hand-made or manufactured masses of adhesive soil was the difficulty in carrying them from the places where they were made to those at which they were to be used when in their moist or soft condition. And this characteristic would be still more felt as a disadvantage when handling the pieces in building or constructing the wall or mound. And when dried, and thus more readily transported from place to place, and more easily handled when used in building, the further step of having some medium by which the dried pieces could be kept together, or in close adhesive contact, would follow. Mortar or cement of some kind would thus be introduced into use.

Unburnt or Sun-dried Bricks—Burnt or Artificially Dried and Hardened Bricks.

This drying of the pieces in the East—the cradle of the human race, as it has been called—was effected solely by sun heat. In those hot climates this is not only very powerful, but its continued influence day after day could be so reckoned upon, that it was a comparatively easy matter to obtain the pieces of cohering soil in a condition of dryness so complete that the whole mass throughout was hard and firm. More than that, this climate enabled the pieces to retain their hardness when built up into wall or mound. In western lands, even if the all-too-brief intervals of sunny weather would have given heat enough to have dried the bricks sufficiently to have made them easily carried from one place to another, and handled in the work of building, such is the humidity of their "weeping climates" that they would have been soon softened by the damp and by beating rains, so that the walls would have become masses more or less shapeless and weak, and the pieces reduced to a soft and in some instances a half-slimy condition. Hence the necessity arose to have the pieces of cohering soil hardened by a more perfect system of drying than that of sun-heat could give; and hence in time came the art of burning or vitrifying them under the intense heat created by the special combustion of fuel, either in heaps or in some simple form of enclosing furnace. How and when this art of burning masses of soil arose, history gives us no note of.

Roman Bricks, or rather Tiles—Modern Bricks and Brickwork.

Hitherto we have refrained from giving to the hand-made pieces of cohering soil the name by which they are now known to us—namely, bricks. The Romans, who used this building material most extensively and ably, formed their pieces of such dimensions that the term "tile" is more applicable to them, or gives at least a better idea of their shape, than the term "brick" as we know it. The dimensions of these tiles varied; and in place of being in form a parallelogram, like our bricks—that is, of greater length than breadth—they were square. The squares ranged from seven inches and a-half up to twenty-two inches on the side. They averaged only one and a-half inch in thickness, or about one-half the usual thickness of the bricks we use. To this, as well as to the care with which the tiles were made, the care taken in setting them, and to the good quality of the mortar employed, must be attributed the lasting character of the work done by the Romans, work which has come down to our day in as perfect a condition almost as when first constructed. This thinness of the tiles or bricks, as we may now call them, used by the Romans, that for reasons which will afterwards be more clear, gives such a bond or stability to the structures in which they were employed, has been imitated, or rather has in all probability been handed down directly to them through the long course of ages, by the Flemish brick-builders of the Low Countries and in parts of Northern Germany. This thinness of bricks as compared with ours is indeed a characteristic of the bricks used generally throughout the Continent. The Germans have long been famous for the excellence of their brickwork. It may, indeed, be said that the finest work existing is to be met with in Germany, and it is to that country that our builders should go to study the capabilities of the material for the higher ranges of architectural work. In this country we almost always associate with the employment of brick structures which, however useful, have comparatively little claim to be architectural works of a high class. The only exception to this is afforded by our domestic buildings or houses. And no doubt it is a wide one, embodying some fine examples of what, with good materials and honest work, brick as a building material is capable of.

Brickwork in this Country chiefly confined to Domestic and the Smaller Classes of Structures; rarely applied to the Construction of Large Public Buildings, as on the Continent.

But brick with us is rarely—we may say never, as a rule—thought of as a material for buildings of a large or public character, and which have claims more or less complete to be considered architectural works. It is to the Continent, as we have said, that we must go to see what brick is capable of doing, with artistic treatment and careful building, in embodying the conceptions in ornamental as well as in plain building. The traveller who has visited several of the Continental countries must have had but small power of observation if he has not noticed, and with admiration, not a few examples of large and fine buildings, especially churches. But it is perhaps in Northern Germany, above alluded to, that the finest brick buildings are to be met with. We might, for example, specify the cathedral at Lubeck as a work showing what can be done with brick in the hands of an able architect aided by first-class builders. With us ornamental brickwork is but a thing of yesterday, and its employment even now is decidedly the exception to the general rule, which embraces plain brick-setting only. And even where ornamental brickwork is attempted, its effects are sought to be obtained by colour chiefly, or by surface work, with the use of variously tinted or toned bricks. We have done little or nothing in the way of giving the varieties of form or outline in brick-setting. But on the Continent there are not a few fine examples—as, to wit, the Lubeck cathedral, above alluded to—of what can be done in giving almost every variety of form in architectural decoration by the use of brick alone. Before leaving the retrospective or historical part of the subject, it will be interesting to note that, although we almost always associate with our conception of Grecian architecture, the finest which the world has ever produced, stone as the material in which its beautiful characteristics have been handed down to us, brick was largely used by the Greeks, and used in a superior way, as indeed they used every material they employed in the fine and the constructive arts.

Kinds or Classes and Qualities of Bricks used in this Country.

Before we proceed to explain the peculiarities of practical brick *laying* or *setting*, in the construction of the various works of the builder, we shall consider, as briefly as may be, the kinds or classes of bricks used in this country, and note some of their characteristics and qualities as a building material. It does not come within the scheme or the scope of the present paper to describe how bricks are made. The details of this class of work may perhaps find a place in this work, should its limits be found capable of embracing them, in a paper in which the work of "The Brickmaker" may be fully explained. Suffice it here to say that the bricklayer will be all the better if he knows something, at least, as to how his bricks are made; and he ought, at all events, to know a good deal as to the qualities of the soils out of which the brickmaker forms his bricks, for this knowledge will be of use to him in deciding the value of the bricks made from the soils of certain localities in which brickmakers have set up their works. The rage for mere cheapness in constructive materials of all kinds —which has extended a desire but too widely that has done more than aught else to deteriorate the quality and to lessen the fame of English work—has not passed by those engaged in brick-building. Hence it is that not only the poorest of materials have been and are still being largely employed throughout the country, but the making up and the burning of those poor materials have been done in the cheapest and therefore the most ineffective of ways. Thus it has come about that an enormous number of houses and other structures have been erected with bricks of such poor quality that the signs of decay may be said to have shown themselves when the buildings have been but a few years erected. In some instances, indeed, months have barely elapsed before this disgraceful condition of things has been evidenced; and, indeed, it would be quite correct in some instances to say that decay has set in before the bricks were used, so utterly worthless as a sound and lasting building material have they been. There is, beyond a doubt, a vast amount of brickwork done throughout the kingdom in which bricks are used which should never have been permitted to come on the ground—the very look of which, to say nothing of any other and usual test, should have been enough to condemn them as worthless for building. It is only right, however, to state that brickmakers and bricklayers are not wholly responsible for this state of matters. Indeed, if the blame is to be placed in the right quarter, it will be found to rest chiefly with the proprietors of houses and with the class of contractors—often, however, practical bricklayers—so well known in modern times as those who "run up" houses made to sell, not to last. There are many who really build for themselves alone, but who will have their work done at the lowest possible price; so that, if the bricklayer is to do the work at all, he is compelled to buy cheap materials; and the brickmaker, to meet his price, is equally compelled, so to say, to make bricks cheap and utterly worthless, when judged from the right standard of building. We do not here enter into a discussion of the points involved in the morality of the question—not that it is or can be apart from the practical points of it, for man not possessing merely physical properties, but possessing other and higher attributes, his *morale* cannot be got rid of as a working element, even if he would get rid of it—but simply because our space does not admit of our pursuing the subject, practical as it is when viewed from its proper standpoint.

The Use of Cheap Bricks to be Avoided where Good Sound Honest Brickwork is Desired.

But this much we may say, that experience has abundantly proved that in this matter of business, honesty is the best policy, or, as we prefer to put it, the best principle; for it will be found that bricklayers and brickmakers who will not pander to the rage for cheapness as such merely, and who will not do other than the best work and make the best materials possible for them, stand not only the highest in business reputation and in moral character, but find in their experience that this principle or policy pays them, and at an infinitely higher scale, than bad work does. And it is matter of pride that this high-minded and high-acting class is a wide one. If it were not so, our material decadence would long ago have been consummated. Some of our youthful readers may deem such considerations as these to have no practical bearing on the subject of our papers; but as they learn the lessons of life they will, we venture to say, find that they have the closest practical bearing on work as it ought to be done. Work done from high-minded motives will be sure to be good work—must be; work done otherwise may be. And the wise man wanting good work done knows which is best—to trust to chance or "may be," or secure a certainty which must be.

The Soils or Earths Used in and Best Adapted for the Making of Sound Bricks.

We have said that the bricklayer or setter will be all the better if he knows something of the work of the brickmaker—at least, that this may or should extend to his knowledge of the material he uses. A soil of the highest quality is obviously necessary to give the best bricks, and the finest soil is that composed of a pure clay mixed with sand. It must be free from pebbles or hard nodules of stone. Soil largely mixed with vegetable matter, or from which clay is largely absent, cannot yield bricks of the highest quality. Lime in excess is not a desirable constituent in brick soil; neither are metallic substances, known as pyrites: these, when present in too large a proportion, act during the burning process prejudicially, forming a species of flux by which cavities or air-holes in the interior of the brick, and cracks or fissures externally, are formed. When fluxing materials are present in moderate quantities they tend to aid the proper degree of vitrifaction required. And on all good bricks this process is more or less partially produced—that is, a species of glassiness is given to the brick, at least on its surface, which aids greatly its damp or wet resisting powers. This characteristic is obtained in perfection when the clay and sand are present in the soil in the right proportions. Soils are sometimes met with in beds of greater or less extent in which those proportions are naturally present; and these constitute "brick fields" of the highest class.

THE ROAD MAKER.

HIS WORK IN THE LAYING-OUT OF ROADS IN RURAL, SUBURBAN AND TOWN DISTRICTS, THEIR CONSTRUCTION, REPAIR, AND IN THE CHOICE AND USE OF THE VARIOUS MATERIALS EMPLOYED.

CHAPTER I.

Introductory.

ALTHOUGH the principal portion of the inland passenger and goods traffic between all towns of any magnitude, and all localities of manufacturing, mining and trading importance, is now by railways, yet the main roads, and the township and other highways, will continue to be of great interest and importance to the rural community of the kingdom. The ordinary road communications throughout the country, which, little more than a quarter of a century ago, ere the present system of railways was established, were those alone in use, still continue indispensable to the requirements of the occupiers of land, the state of such communications having great influence on the value of landed property. And as the cost of maintaining the public highway still continues, as heretofore, to be chargeable upon the land; the owners and occupiers of landed estates have therefore every interest in the highways being kept in the best condition, and repaired at the least expense. It may be taken as an axiom—too frequently, however, overlooked—that the more complete and perfect the manner in which a road has been constructed, the more easily, and at less expense, will it be kept in repair. However strange it may appear, it is none the less true, that whilst no difference of opinion exists as to what constitutes a good road, it is yet not a matter of universal agreement as to what are the best means of attaining that end. This anomaly arises from frequent ignorance of the correct principles on which the goodness of roads depends; and it is with a view to point out, for the benefit of those it may concern, such principles of construction as will secure so desirable a result as the attainment of good and easily maintained roads, that the following brief treatise has been undertaken.

First Essential in the Construction of a Good Road.

Dryness of soil on which a road is constructed is the first essential to its goodness. A road, to be a good one and easily kept in repair, must have the soil on which it is made of such a nature as to bear the weight of any traffic brought upon it without any shrinking or displacement of its particles. The soil should, in fact, constitute the road, and the covering should only be considered as a hard and tough matter interposed between the weight of the traffic and the road to support it, to protect the latter from abrasion of its surface by the motion of the former. And this to serve the same purpose that a thin sheathing of hard metal is frequently used for—as a covering for wood, or any soft material of sufficient strength for its purpose, to protect such wood or other material from injury by the friction of a heavy body in motion upon it. A road, to be considered good, should not, in any degree, be dependent upon the covering of stone for supporting the weight of the traffic upon it; otherwise no thickness or goodness of the material of the covering will prevent the soil of the road working through it, and thereby speedily lapsing into a ruinous condition.

Disadvantages of Wet Clay Soils for Roads.

The soils most liable to work through the stone covering of roads are wet clays, particularly blue gault or drift clay, wet or loose sands, wet peat soils, and bogs or morasses. In fact, any soil containing stagnant water is incapable of bearing the weight of traffic upon it; and any road made upon such soils will rapidly be out of repair, however thick and good its stone covering may be. The first thing, then, to be done in road making is to have the site of the road thoroughly drained, if the soil contains stagnant water.

Although dryness of the soil in which a road is made is the first essential of its goodness, yet there are many other properties equally important and necessary to be attended to in its construction. The properties alluded to will be separately discussed in the following paragraphs of the present series of papers.

The Form of Road in the Direction of its Route or Leading Gradients or Inclines.

For safety in descending, and economy in conveying traffic in ascending hills, as well as in maintaining roads in repair, steep gradients or inclines in the route of roads should be as much as possible avoided. The greatest portion of travelling, and also of heavy traffic in the conveyance of goods, having been transferred from common roads to railroads, there may not be at the present day the same reasons for having roads without steep gradients—either for the safety of persons, or for the saving of animal labour in the conveyance of goods—as there were in former times. Notwithstanding this, as common roads are still used to a considerable extent for travelling in vehicles drawn by horses and moving at a considerable velocity, and also for the conveyance of bulky and heavy loads, the limit of safety in the gradient should be by no means disregarded, either in designing or laying-out a new road, or in altering the direction of an old one. The limit referred to is such, that the gradient, in attaining a height to be passed over, shall be safe for carriages travelling at an ordinary speed. The ascent must be so limited that the friction of the carriage shall overcome an accelerated velocity in descending an incline. This limit may be ascertained by the force required to produce and maintain motion in a carriage on a level road. In this the weight of the carriage will be proportional to the base, and the force required to produce and maintain motion of the carriage to the height, of the inclined plane down which the carriage may descend without accelerated velocity.

The Angle of Inclination, or of Friction in Roads.

The angle of inclination which will produce an equilibrium between the friction of a carriage and the force of gravitation to produce accelerated velocity, is called the *angle of friction*, and it varies in roads of different construction and materials. *The rate of inclination of the angle of friction* is the proportion of 1 to the quotient arising from dividing the weight of a carriage by the force required to produce and maintain its motion on a level road.

Force or Power required to move a Carriage on a Level Road, and on Roads of Different Gradients or Degrees of Inclination.

The force required to produce and maintain motion of a carriage weighing one ton has been ascertained by the experiments of Mr. MacNeil on roads of different constructions and materials. The "force," or the "friction," on different road surfaces which are level, are here given:—

(1) Well made pavement, 33 lb.; (2) Broken stone surface or old flint road, 63 lb.; (3) Gravel road, 147 lb.; (4) Broken stone road, on a rough pavement, 46 lb.; (5) Broken stone surface, on a concrete bottom formed of Parker's cement and gravel, 46 lb.

The following gives this: the numbers corresponding to those in last paragraph showing the inclination of the roads.

(1) 1 in 86; (2) 1 in 35; (3) 1 in 16; (4) 1 in 50; (5) 1 in 50.

The results in the last paragraph are the maximum rates of inclination to insure safety in travelling—with the materials used as named in the first paragraph—in descending inclined planes in the direction of public roads; but another, and scarcely less important consideration in laying-out a public road, is economy of the labour of the draught cattle.

Economy in the Drawing Power of Animals on Roads—Influence of Gradients in Draught.

The absorption of power in ascending inclined planes, is shown by a table given in the article "Road," in Morton's "Cyclopædia of Agriculture," in which a comparison is given of increased distance as an equivalent of that on a level road, as due to the vertical height of various slopes of different rates of incline. From this we have prepared the following:—

If we take as the draught or moving force, on a road having an incline or gradient of one foot vertical—or rise—in every five hundred feet an equivalent of that on a level road of 1·102—a level road being unity—we find that if the gradient be increased to so great a rise as one foot vertical in every ten feet horizontal, the draught will be as much as 6·067. The intermediate gradients, or rises, with their equivalents, are given as follows:—1 in 400=1·128, 1 in 300=1·170, 1 in 200=1·255, 1 in 100=1·510, 1 in 90=1·566, 1 in 80=1·637, 1 in 70=1·728, 1 in 60=1·850, 1 in 50=2·019, 1 in 40=2·274, 1 in 30=2·699, 1 in 20=3·538, 1 in 10=6·067.

Influence of Gradients or Steep Inclines on the Durability of Roads.

So much for the effects of inclined planes in the course or direction of roads, both as to the safety of travelling in wheel-carriages in descending, and as to the economy in the labour of draught cattle in the conveyance of loads up the ascents of inclined planes. The last matter for consideration on this topic is the effect of inclined planes in the direction of roads, on their maintenance in repair, and on their durability. Whoever may have made any observation on the state of a road upon an inclined plane, compared with that on a level, will not have failed to discover that in proportion to the steepness of the incline, the materials of the covering of roads are more liable to become loose and be displaced, from whatever cause such loosening and displacement may arise. When the incline is so steep as to require that the friction of a carriage descending upon it be increased by the use of drags, skids, or brakes, to compensate the force of gravitation in producing accelerated velocity, the dragging or sliding action of the wheels occasions great amount of wearing in the covering of the road, and a much greater amount and cost of repair of the road, than when the incline is not so great as to require recourse being had to such expedients.

Deviations in the Direction, Junction and Crossing of Roads—Mode of describing the Curve for Road Junctions, etc.

In a deviation from a straightforward direction of a road, the bend or change of direction should be as great or obtuse an angle as circumstances will admit of; and where it is possible, the bend should be by an easy curve instead of an angle, and the lines of the deviation should be tangents to the curve. The best curve for the purpose referred to, and also for the junctions and crossings of roads, is a parabola. The following gives the mode of joining two converging lines, given in position, as two deviating directions of a road, by a parabolic curve. Let *a c* and *b d* (fig. 1) be two converging lines, given in position. Produce *a c* and *b d* until they meet in *h*. Join *c* and *d*, and bisect the line *c d* in *g*. Join *h* and *g*, and bisect *g h* in *p*, which, by the properties of the parabola, is a point in the curve. Join *c* and *p*, and *p* and *d*, and bisect the lines *c p* and *p d*, severally, in *i* and *k*; bisect *c h* and *h d*, severally, in *e* and *f*, and join *e* and *i*, and *f* and *k*, and bisect the lines *e i* and *f k*, severally, in *p* and *p*; then *p* and *p* will be points in the curve of a parabola, The third point is at the *p* between *h* and *g*. Join *c* and *p*, *p* and central *p*, *p* and *p*, and *p* and *d*; and bisect the lines *c p*, *p p*, *p p*, and *p b*, severally, in *m*, *q*, *s*, and *u*; also bisect *c e*, *e p*, *p f*, and *f d*, severally, in *n*, *r*, *t*, and *v*; join *n* and *m*, *r* and *q*, *t* and *s*, and *v* and *u*; and bisect the lines *n m*, *r q*, *t s*, and *v u*, severally, in *p*, *p*, *p*, and *p*. A curve drawn from *c* through *p*, *p*, *p*, *p*, *p*, *p* and *p*, to *d*, will be a parabola, to which the converging lines *a c* and *b d* will be tangents at the points *c* and *d*.

The mode of setting out the curve in question on the ground is so obvious from what has already been shown as not to require any further remarks for its elucidation; and the operation will only require the use of a chain or tape line to measure distances, a few straightening poles, and some pickets to mark the positions of all the points marked *p*, as the same are found in the operation described.

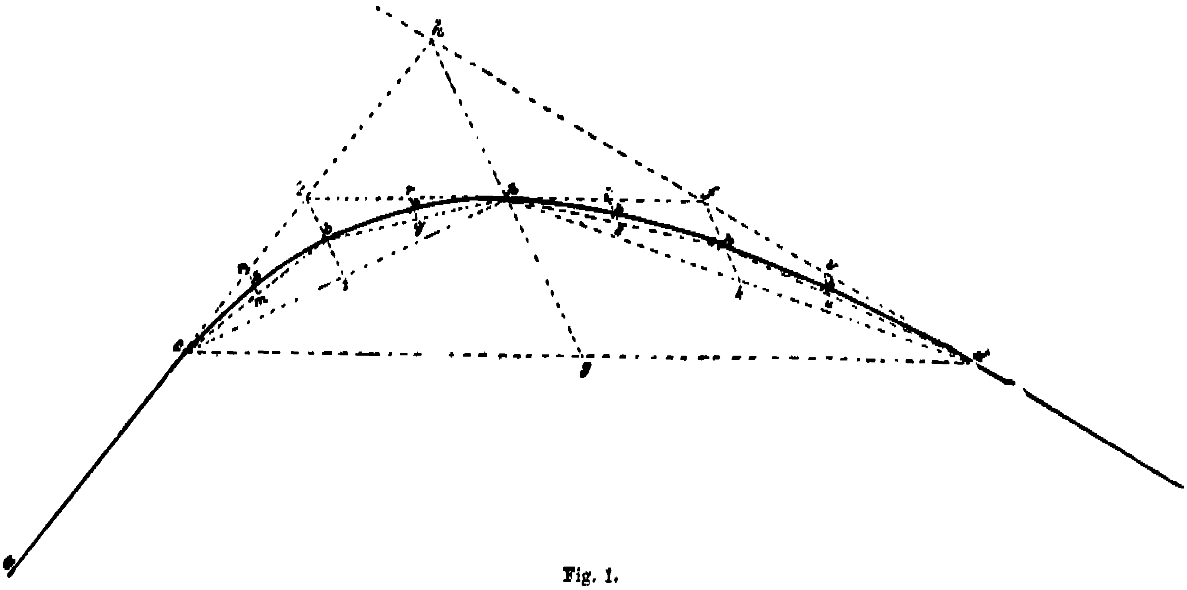


Fig. 1.

Roads crossing Rivers or Ravines.

Whenever a road is carried over a river or ravine by a bridge, it should, if possible, be at a right angle to the direction of the stream or glen, as a bridge with a direct span is not only less difficult and costly in its construction, but stronger, than an oblique or skew bridge; and the bridge, if its direction be not in that of the road, should be approached at both ends at as obtuse an angle as possible, and the bend formed by the direction of the bridge with that of the road should be by a parabolic curve, to which the lines of approach should be tangents, as directed in the last paragraph.

The Breadth given to Roads.

Having fixed upon the direction, the next matter for consideration in laying out a new line of road is its breadth. This will depend upon the amount of traffic for which the road, at the present or a future time, may be required.

No public highway for wheel-carriages should, under any circumstances whatever, be less than fifteen feet wide, clear way; twenty-four or thirty feet will be more frequently required; and for some distance from the entrance of populous towns—particularly of those having numerous and populous suburban villages in their neighbourhood—a breadth for a main or high road of fifty, sixty, or even seventy feet, may be necessary. In addition to the breadths just mentioned for carriage-ways, roads leading direct to towns should be provided with a footpath, six, nine, or twelve feet wide, according to the population of the town to which the road leads; and a path for saddle-horses, nine or twelve feet wide, may also be an advantageous appendage to main roads near towns. The following rule will here be found useful.

To find the area of ground that will be required, per chain or per mile, for a road of any given breadth in feet. Multiply the given breadth of the road in feet by 66 or 5280, as the result may be required per chain or per mile respectively, and the product will be the area in square feet, which divided by 9, the quotient will be the area in square yards, and which last result being divided by 4840, the quotient will be the area in statute acres.

THE CARPENTER AND HIS TECHNICAL WORK.

ITS ORIGIN AND EARLY WORK—PRINCIPLES AND THE DETAILS OF ITS PRACTICE.

CHAPTER II.

The Origin of Joints—The Half-Lap Joint.

IN the preceding chapter we concluded our remarks under this head by pointing out how, in joining two pieces of rough or "round" timber, as it is technically called, they would lie more "sweetly" together if the two ends were flattened, as at *d* in fig. 12 (*ante*, p. 14). Now, we can easily conceive one of the early carpenters or builders in wood, engaged in preparing the end of a piece of timber to be joined to another in this way, being led to try the effect of cutting the end surface away till a considerable depth in each piece was obtained. In placing them together he would find as a consequence that the projections, as at the points *e* and *f* in fig. 12, would be lessened or lowered just in proportion as the cut at *d* was made the deeper. A little thinking out of this consequence would lead him to conclude that a point of depth would be reached some time, in continuing to deepen the cut, as at *d*, which when reached and the two pieces put together, the upper part of the piece *a a* would "range with," so to express it, or be in a line with, the upper face or line of the piece *b b*, or, to use the technical term, "be flush." The same would hold true of the under sides. The position of the two pieces would be as shown at *a b* in fig. 13, the joint between them assuming the form as at *c*. The end of one of the separate pieces would be as at *d c*; and the depth of the part *c f*, or *d g*, would be found to be exactly equal to half the depth, or the two together to the whole depth or diameter of the tree or branch, as at *h*.

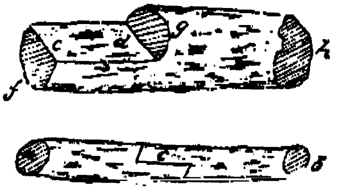


Fig. 13.

Here we have a true "joint"; and following upon that shown in fig. 12, which was in all probability the outcome of the first necessity—namely, to lengthen out short timbers—we may safely conjecture that it was the first true joint used. It is still used, and largely, in carpentry, and in joinery often, and is known as the "half-lap joint," as at *c* in fig. 13, the simple lap (over), or full "lap," being that in fig. 12 at *e f*; at fig. 9, in last chapter (page 13), we have given a drawing of a half-lap joint in section, and in figs. 10 and 11 later and more advanced forms of what are called "scarf" joints, which grow out of it.

Continuation of the above Subject, with Practical Examples.

In fig. 3, in the last chapter (page 12), we illustrated, as one of the typical joints, a square joint—a method of joining a horizontal piece of timber to a vertical one. This forms one of our most elaborate joints, but we can easily conceive how it was preceded by other forms of a much simpler character, of which probably its first form was discovered in connection with a part of construction which in its direction would be as elementary as that of tying or binding two pieces together, as in fig. 12, at *a a*, *b b*. This would be the connecting with a horizontal piece two vertical posts or timbers stuck or forced into the ground to form, say, the side of an enclosing space, as a hut. At first, the enclosing wall, so to term it, of a hut or hovel would be formed by a series of branches, nearly of equal size, placed close to each other both for strength and for shelter from wind and rain. In process of time it would be seen that the purposes of shelter would be obtained as readily, where shelter was more essential than mere strength, and without the use of so many thick or strong branches, by having the stronger ones placed at intervals in the ground, as at *a a*, *b b*, fig. 14. The tendency of the posts to separate from or to fall towards each other, if left unsupported—a tendency the stronger the higher the posts, so to call them, or the thinner they were—would be counteracted by introducing a third piece of timber—technically now called a "member." This would naturally be placed horizontally, as at *c c*, and at first would be secured to the posts at the two points in the simplest way—by tying them together with some vegetable fibre or the branch, as of that of a willow, as in fig. 12, at *c*. A number of these horizontal pieces placed at intervals in the highest of the posts, as at *d e f*, would obviously give facilities as holding-places for interlacing the

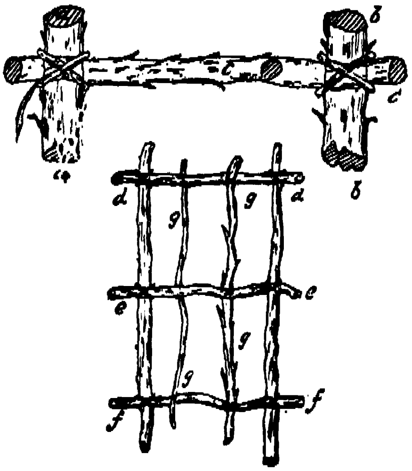


Fig. 14.

smaller branches, as *g g*, running vertically. Those with their interstices filled up with leaves, or, better still, moss, which would be found to be valuable for many purposes, would form a screen or wall, so to call it, which, for preventing access to wind or rain, would form no contemptible enclosing surface.

But this arrangement, while it would be proved to give strength with fewer strong vertical timbers or posts, would be seen to be an ugly or awkward joint, possessing all the defects of that at *e f* in fig. 12. The desire for even surfaces—that is, the absence of all projecting parts—would soon be created, and some method of obtaining this in the present instance would follow. Possibly the first attempt to have the horizontal piece at its ends either within the line of the vertical pieces in *a a*, *b b*, fig. 14, or in line with them, and what is technically now called "flush," would be a simple system of "notching." Thus, as at *a*, in fig. 15, the end of the horizontal piece being shaped as at *b*, to go into the notch. In time this notch would be enlarged and made rectangular, to give better bearing surfaces, as at *c*, the end of the horizontal piece *d* being formed to fit as tightly into it as possible. But while this forming of joints would keep the vertical posts, as *a a*, *b b*, in fig. 14, from approaching each other or bending inwards, they would not prevent them from leaving each other or bending outwards. And if they did so sufficiently far, the ends of the horizontal piece, as *b*, fig. 15, would drop out of the notches, as at *a*, and the connection would cease The joint at *c* would be better, as it would give the opportunity of joining the end *d* of the horizontal piece tightly into the cut or slot or groove *c*.

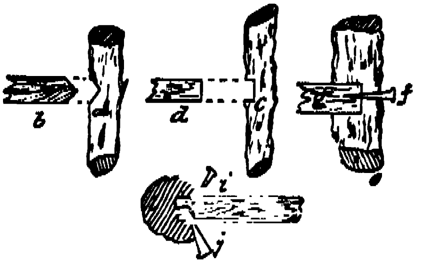


Fig. 15.

Trenails, Keys, and Wedges, as used in Carpentry Joints.

Simple a contrivance as a "nail" seems to us, it is in reality a great invention, and it would be some time before it was added to the thousand-and-one contrivances which the ingenuity of man has discovered and applied to aid him in his daily work and meet his daily wants. There is little doubt, we think, but that the wooden spike long preceded the iron nail, just as we know the era of timber construction came before that of stone, and gave birth to some of its contrivances and special features. And we can easily conceive of the idea of the spike or wooden nail having originated in some such simple way as passing through a heap or mass of material, such as leaves or brushwood, which it was desirable to keep in one position while lying on the ground, a long and slight and sufficiently strong stick. This passing through the mass and entering the ground or soil would obviously secure the mass, binding it more or less firmly to the soil. Or the idea of the spike may have originated in the desire to bind or keep together the mass of branches, twigs and leaves, etc., which formed the walls or enclosing surfaces of the early huts or hovels of our ancestors. By passing sticks through the thickness of these containing walls at intervals, it would be found that the inner surfaces and outer would be bound together more or less compactly, And it would almost immediately follow upon this or a similar use of small or short pieces of timber that they could be more readily and certainly used if one end was pointed or reduced in thickness. Once the idea of *penetration* took possession of the mind of the constructor, many useful applications of its principle would follow, and his earliest work in connection with his tilling of the ground to receive his tiny crops—the first of necessity of all the arts—would give him this idea of penetration. The wooden spike or "trenail," as in modern technical language it is called (which obviously was once written "treenail," as it is literally a nail made out of a tree), would soon form a very common feature in timber work of all kinds. We have said that the joint, as at *c d* in fig. 15, would depend for its continuance in force upon the tightness with which the end *d* of the horizontal piece was jammed up into the cut or groove *c*. But as timber shrinks and swells—contracts and expands, to use the technical terms—according to the dampness or dryness of the atmosphere; in dry weather the joint thus secured by jamming up would loosen, and the connection between the pieces would cease or be weakened. But the spike or trenail would obviously come in here to serve a useful purpose. It might be used in the way as shown at vertical section of a post *e e*, fig. 15, the spike being driven in from the back, as at *f*, penetrating the end of the horizontal piece *g*. Or it might be driven in from the sides, as at *i*, in sectional plan of the post, at *l*; or two pins or trenails might be used, as at *i* and *j*, one driven from each side. The wooden "key," as it is technically termed, is another contrivance for keeping two pieces "jointed" well secured together, and frequently used to prevent the one piece slipping or being moved away from the surface of the other piece. Its use in this last way is illustrated in fig. 4 (*ante*, Chap. I., p. 12), given in the paragraph entitled "Representative or Typical Forms of Joints," where its position in each section, as at *b*, is shown. The "key" is in this and in similar work a small block generally square in section, and of length equal to the "seat" or groove into which it is passed; the length of the form *b* in fig. 4 (*ante*) being equal to that of groove *d* in lower diagram. Grooves or seats are cut in the lower edge of the upper piece *a a*, and in the face of the lower piece as at *d*, and the "key," as *b*, being forced into the groove *d*, the upper piece, as *a a*, is placed in position when the key *b* enters or is forced into the groove on its lower edge. A wedge is another form of key, and is so called from its tapering form. One form and mode of using it is shown in fig. 6 (*ante*) at *d d* and *i i*. Many examples of the use of trenails, keys and wedges will be found in succeeding chapters, and also of "iron screw bolts" and iron "straps," which are much used in modern work to secure timbers together.

Interpenetration a Distinguishing Characteristic of Joints in Carpentry.

Allusion has been made in the preceding paragraph to the principle of penetration as one of great importance in the art of carpentry. The pupil will perceive, as he proceeds to consider the matter to be given hereafter in this series of papers, how this principle, either in its partial or full development, is concerned in nearly all the operations of carpentry. It is the vital principle on which all joints or junctions of timber where one piece is connected with or supported by another piece chiefly depend. Some of the developments of this important principle constitute a series of problems the most interesting, as some of them are the most intricate, of what may be called the "geometry of carpentry." (See the series of papers in this work entitled "The Building and Machine Draughtsman.") The first, as it is the most simple of the practical methods of carrying out this principle of penetration, would in all likelihood be the forming a hole or aperture, as *a*, in fig. 16, passing through from side to side, in one piece of timber, say a vertical post, as *b b*. The horizontal piece to be supported, as *c c*, may be passed through, as in section of post *d d*, and it may be secured from slipping by the spike *f*, called popularly a "pin," or in technical phrase a "trenail," or a "key" might be used, passing through the post *e e*, and penetrating the horizontal piece as shown. In place of using one long horizontal piece, resting it in the aperture in the post, in or about the middle of its length, two short pieces will give the same result, one being passed—"entered" is the technical phrase or term—from one side, as at *g*; the other from the opposite side of the hole, as at *h*. They might stop short of meeting in the interior of the aperture, leaving a space, as at *i*, between them; or they might have been brought in contact with each other, as at *j*. When so placed in contact with each other the one piece is said, in technical terms, to "butt" against the other, and the ends of each piece constitute what is called the "butting face" or surface.

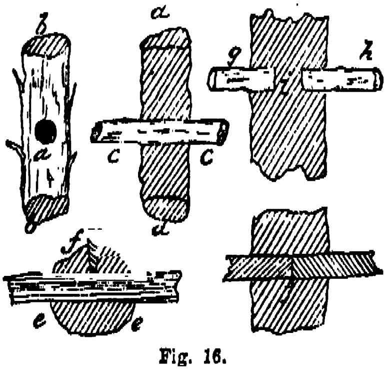


Fig. 16.

We have in preceding paragraphs given illustrations and descriptions of what we have designated as "representative forms" of joints, and of the probable way in which joints originated, or were invented. Before proceeding to take up the systematic consideration and illustration of the different classes under which the representative forms named are ranged, we deem it best to introduce here, as connected closely with what is to be given under this section of our papers, some remarks, and to give a few diagrams illustrative of "framing" or "framework," and of some points connected with its original introduction. And as preliminary to these, we preface them by some remarks on

The Methods of Dealing with Timber, Trees, or Parts of Trees, in the Early Constructions of the Carpenter.

Timber would for long be used in the "round" (see paper entitled "The Timber Dealer"), to employ a modern technical phrase still used to denote this the oldest employed of forms of the material. It would take some time before tools were so perfected that the round timber could be formed into timber with squared sides or with flat surfaces. The tool for doing this would, in all probability, be the axe; this followed by the adze, which is simply the axe with its edge so turned in relation to the handle that it can be used for slicing off plates, so to call them, from the surfaces of timber in a way much more conveniently applied and more rapid in its work than the axe. The chisel would soon be invented, and its use for smaller work would soon be appreciated. The saw would early and for long be the great tool of the carpenter; for with it he could do almost every kind of work required, even for the more complicated and complete structures which would follow on the simple booths or huts of branches, twigs, and leaves. (For terms see "The Cyclopædic Dictionary of Technical Terms.")

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER II.

Third Process: Preparing the Calico with "Soluble Oil."

In a great many colours, especially those of artificial alizarine, it has been found that when the cloth, after the usual bleaching process, is treated with a preparation of oil known as "soluble oil," "oil prepare," and other names, the colours are developed in greater perfection and in shorter time. And although it is not necessary that the cloth for all colours should be so treated, it will be most convenient to treat of this subject in the present division.

The fixed oils, such as castor oil and olive oil, are compounds of glycerine and a fatty acid. When they are treated with an alkali such as caustic soda, a chemical reaction takes place, the oil or "glyceride" is decomposed, the fatty acid combines with the soda, the glycerine being thus left uncombined. The compound of the fatty acid with the soda is simply a soap, being soluble in water, and which lathers, or may be beaten into froth. When now we add to this mixture excess of an acid such as hydrochloric acid, it decomposes the soap or emulsion, and unites with the soda, forming, in the case of hydrochloric acid, chloride of sodium or common salt, setting the fatty acid free. If now we let the mixture stand, the fatty acid, being lighter than water, rises to the top and may be removed, leaving behind the glycerine, common salt, and excess of acid. If we add to this fatty acid the proper quantity of solution of soda, we obtain an emulsion, which is soluble in water, forming, when dissolved, a milky-white solution. It is this emulsion, known as "oil prepare" or oleine, that is applied to the cloth for the purpose above mentioned. Many colours printed upon calico prepared with oleine and dried, have their development hastened and their beauty and brightness increased.

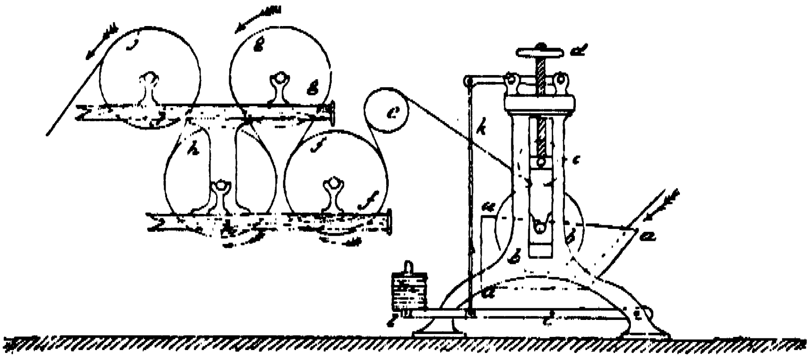


Fig. 5.

Fig. 5 shows the process of preparing the cloth with this emulsion. The bleached calico passes into a box (*a a a*), which contains the oleine diluted with water, passes two rollers fixed at the bottom of the box; then passes between two rollers to remove superfluous liquid, as shown in the figure, *b* and *c*; the latter being a small brass roller turned by power, and which can by the screw and lever *d* be pressed with any amount of pressure upon the lower or larger wooden roller *b*, which of course thus turns in the opposite direction and draws the cloth between them. The calico then passes on to an "expander," *e*, or roller with ribbed surface, to stretch out the cloth tightly, and then is dried by the steam cylinders, as shown in the figures. The expander, which is very largely used in print-works operations, is simply a wooden bar with a plate of copper or brass fastened on its upper surface, which has for half its length ribs running diagonally in the direction from middle of bar to end, and for the other half ribs running in the opposite direction, as shown in fig. 6.

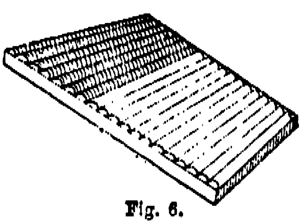


Fig. 6.

Oleine is made from a variety of oils, but preferably from the best olive or castor. Good castor oil oleine is made in the following manner: 470 lb. castor oil, 67 lb. caustic soda in powder, and 98 gallons water are boiled together for about two hours. Of the emulsion so obtained 33 gallons are mixed with 5 gallons hydrochloric acid at 25° Tw., and 12 lb. common salt—the salt being added for the purpose of rendering the liquid heavier and so enabling the fatty acid, *i.e.* oleic acid, to float on the top more readily. Run off the liquid at the bottom, and add to the oleic acid 3½ lb. caustic soda dissolved in 10 gallons water; mix well, cool, and add 3 quarts of ammonia, and the oleine is ready for use. For preparing the cloth dilute this oleine 16 times with water.

Preparing the Colours used in Calico Printing—Colour-Mixing.

All the printing compositions used by the printing machine are prepared in the works. Be it a dye-stuff or simply a mordant or discharge, etc., it requires to be properly thickened, to enable it to be printed; and most colours require a considerable amount of preliminary treatment before they are ready for the machine.

The composition ready for printing is always termed "the colour," whether it really contains any colouring matter, or only some substance such as a mordant or a "resist," which is in some way connected with the formation of the printed effect. This preparation of the "colour" or composition used in printing is called "colour-mixing," and the room set apart for its execution is called the "colour shop."

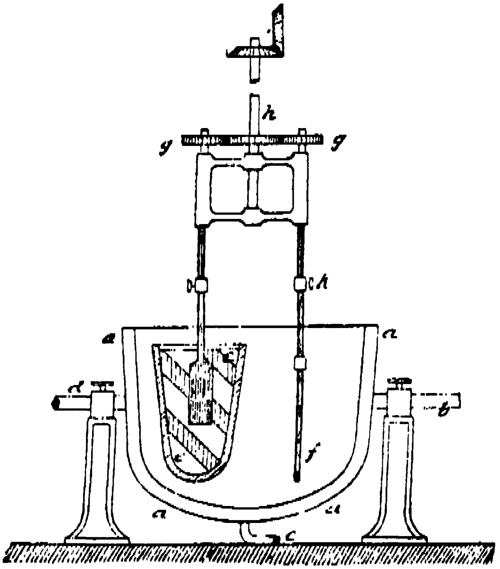


Fig. 7.

The Colour Shop and its Machinery.

The colour shop should be a large square or oblong room, with the floor well grated for the escape of the water, and with a portion of the roof raised and provided with efficient ventilators. When ventilation is deficient the room soon becomes filled with the constantly escaping steam, and the operatives being unable to see clearly, confusion and mistakes are the result. In the centre of the building, or along one side thereof, is the row of vessels for boiling, or range of colour pans, varying in size from 1 to about 100 gallons capacity. The colour-pan is heated by steam, which circulates through a jacket surrounding the vessel. It is formed of two sheets of copper, each beaten into the required shape, the one a little smaller than the other, so as to fit into it and leave a space between of about an inch. These are strongly riveted together, as shown in fig. 7, which is a section of a colour pan. *a a a* is the copper pan, with double sides forming a steam jacket, the steam entering at *b* and escaping at the tap *c*; the pan swings on pivots, *b* and *d*; at the latter is a water-tap for circulating through the jacket cold water for cooling the pan. *e*, *f*, are the mechanical stirrers or agitators, which are worked by three toothed wheels at *g*, the centre one being attached to the vertical shaft *h*, which conveys the power; the other two wheels are attached one to each agitator, and so arranged as not to clash against each other. When the agitators are not required they are detached at *k*. When the pan is to be emptied of its contents the catch is unfastened and the pan is swung over. There are several forms of colour pans, but in principle they are the same as that we are describing; thus in England many colour shops have the colour pans stationary, with a hole at the bottom plugged up with a wooden bung when the pan is filled, and removed for cleaning out. It will readily be seen that the mechanical stirrers require occasional assistance of hand-stirring, as the colour adheres to the sides and bottom of the pan, beyond the reach of the agitators.

Some new agitators replace the laborious process of stirring by hand very successfully, being made to scrape away the colour from the sides and bottom of the pan.

In boiling the colour, the steam should be turned on gradually until the pressure is from 7 to 10 lb. When the colour is boiled sufficiently the steam is stopped, and the water turned on in its place, until the colour is cool enough for the addition of other ingredients, or for "straining." The operation of straining the colour is a very important one in colour-shop labour. If all lumps and gritty matters be not removed, the finely-engraved copper rollers may be scratched. The colour is strained by forcing it through a strong open cotton fabric called straining cloth; unless the colour is thin enough to run through the meshes of the fabric without forcing, the colour is poured into the cloth stretched over a tub, and the corners gathered up together, held firmly in the left hand, while the colour is, by means of wringing and pressing, forced through the cloth, leaving lumps and other impurities behind. Many attempts, successful and unsuccessful, have been made to construct straining machines, the principle of most of which is the creation of a vacuum beneath the straining-cloth or sieve, but they have been found to be advantageous only for such colours as are made in very large quantities.

Principles of Colour-Mixing.

Between the manual labourer of a large colour shop who actually "mixes" the colours, and the directing "colour-mixer" who understands their composition and properties, there is as wide a difference as between

the mechanic who merely makes a wheel or shaft of a machine of secret invention and the inventor himself. In each case the labourer carries out the orders of his master or foreman, whether he understands the reason or not.

Practical Work in the Colour Shop.

The subjects of the chemistry and uses of the various dyes, thickenings, and other "drugs" employed in calico printing, being treated in another portion of our work, we now proceed to sketch, as fully as the space at our disposal will admit, the practical work of the colour shop in preparing those substances for actual use in the printing machine.

In the economy of the colour shop, where a great number of separate "batches" of different colours of different strengths are made, the method always adopted is to keep in stock sufficient supplies of ready-prepared thickenings, mordants, and standard solutions of the various colouring matters. Hence it is generally only necessary to mix measured quantities of thickening and of solutions of colouring matter, etc., to form the "colour" in a state ready, after strainings or other treatment, for the printer.

1. Thickening Pastes.

Starch.—First, a large supply of *starch paste* is kept in stock, being a paste made by boiling wheaten starch and water in the proportion of about 1¼ lb. per gallon; a supply of starch paste is also kept at 2½ lb. and 3 lb. per gallon for such colours as require it. From starch paste, again, are made other pastes, by mixing with colour standards or solutions of dyes so as to make strong colours which may require "reducing" or making more dilute by mixing with different proportions of more starch paste as required. Starch thickens better in the presence of a little acetic acid; 1 gallon at 8° Tw. in every 16 gallons of water used yields a good paste. The same quantity —or a larger if economy will admit—of olive or rape oil is a further improvement, the paste being then of a better consistence for mixing.

Flour.—This thickener is prepared for use by boiling 1½ lb. per gallon of water. This forms an excellent thickening paste, in consistence like starch paste, but more "gummy." It is used chiefly for dyed alizarine red mordants. The paste will only keep a very short time; it decomposes in two, or a few more, days, according to the weather.

British gum is boiled with water at about 3 lb. per gallon. This gives a brown, tenacious solution, having properties somewhat resembling gum arabic solution. This solution is used in a great variety of colours. It differs, as a thickener, from starch chiefly in being of a gummy nature; it "works" or "furnishes" in the machine better than starch; and hence is used in conjunction with starch—a much superior, but more expensive thickening paste being thereby obtained, which not only "furnishes" better, but keeps longer without deterioration—British gum being less readily acted upon by chemicals and the atmosphere than starch. Those and similar points defining the uses of the various thickeners will be treated more fully in the chapter on "The Chemistry of Thickeners."

Gum dragon or tragacanth solution is prepared by steeping the gum in cold water at about 1 lb. per gallon for twenty-four hours, and then boiling for four hours, which gives a peculiar thick, transparent, almost colourless, jelly. It is used chiefly for alizarine reds on account of its transparence and absence of colour, and the ease with which it may be washed off the cloth after the colour is fixed; it is also used along with British gum, etc., in pigment colours for similar reasons.

Gum Senegal, or Arabic, or Barbara, or Gedda, is prepared for use by boiling about 6 lb. per gallon in water till dissolved; which gives a thick, strongly gummy solution of rather light colour. This is used almost solely for blocking, as it gives out the finest pale shades, and is easily washed off, leaving the colour pure and clear on the cloth.

Albumen paste is prepared for use by steeping blood albumen at the rate of about 5 lb. per gallon of cold water till dissolved, and then straining. There is generally added to the solution, previous to use, a minute quantity of solution of sulphate of zinc, which causes a sort of semi-coagulation; the mixture becomes several times thicker, without losing any appreciable amount of its fixing power. This greatly economises this otherwise expensive thickening. Blood albumen is used only in mixing pigment colours, to which it of course acts both as thickener and fixer of the colour. The solution is of dark colour, very viscid and adhesive. For very light shades of pigment colours *egg albumen* is used instead of the above. It is dissolved at the rate of 5 to 10 lb. to the gallon in the same manner as blood albumen. It yields an almost transparent colourless solution. Sulphate of zinc is never employed with egg albumen. Both egg and blood albumens putrify when kept many days in solution, but this decomposition may be delayed by the addition of a minute quantity of carbolic acid.

Thickening Pastes used for Special Classes of Colour.

The above are what may be termed simple thickening pastes; the following are the most important special thickening pastes used for different classes of colours. However, to treat in detail of all the various thickening pastes used in different colour shops would be impossible; a few of the most general only can be given, and this we shall proceed to do in our next chapter.

THE DOMESTIC HOUSE OR HOME PLANNER OR DESIGNER.

THE WORK OF THE YOUNG ARCHITECT OR BUILDER IN THE DESIGNING OF HOUSES FOR TOWN AND COUNTRY.

CHAPTER I.

Introductory.

OF the various classes of buildings, to the planning and construction of which the young architect looks forward with the bright expectation of youthful hope as the work of his future "professional practice," for which we suppose him to be now preparing, there is none of so much importance, not one which demands so much of his thoughtful care, as that connected with Domestic Architecture. This does not ignore or in any degree minimize the importance of the classes of larger structures open to his practice. But domestic structures constitute a class of which the varieties are more numerous, and the demand for which, taking the aggregate of individual cases, is the greatest; and the probability is therefore the more certain that for a period at least of his early practice the young architect or builder will be called upon to do more work of this kind than that of a more ambitious character.

Health Influenced by House Arrangements.

The young architect has to bear in mind this important truth—that our domestic structures being those in which we live, in which many spend virtually the whole, and in which many others spend a large proportion of their time, the health and the physical comfort and well-being of the members of the community are more dependent upon and influenced by the proper arrangement and construction of their houses in the living or entertaining rooms in which they sit for a considerable portion, and in the bedrooms in which they spend the whole of their sleeping time, than by the character of buildings such as theatres, churches, or the like, which they only occasionally frequent, and in which sanitary and convenient arrangements are more or less neglected.

Domestic Comfort Influenced by House Arrangements.

Nor is this matter of health, all-important as it is, the only point which comes up for consideration in connection with the houses we habitually live in. Men engaged in business which takes them away for a large part of the day from their "homes" escape for a time from such influences as their ill-constructed houses may bring into active existence. But their wives and families, and those who make up the domestic establishment, be it small or great, cannot so escape from such malign influences, if they exist, as in a too great majority of cases they unfortunately do. But this is not all. For the domestic work of a house involves much more than what is connected with health. The claims of living are much wider than this. To insure comfort in living in our homes, a wide variety of work has to be attended to, and this attention is required to be continuous. Coming up from hour to hour, from day to day, the various details of home comfort, or convenience—to use another term frequently employed—are undergoing a course of perpetual repetition.

The Question of Economical Management of Time Influenced by House Arrangements.

Any one of the details which in their aggregate go to make up what is called "house work" may be considered by itself as a mere trifle. But when this has to be attended to not once, but many times in the course of a day, the mere time which is consumed in this makes the matter assume a totally different aspect. If we ask what really makes up what we call the comfort of daily life, we are constrained to confess that it is simply an aggregation of little things which, in the generally too loose style of daily conversation, we persist in calling "trifles." It is the little things in house work which are ever cropping up, always crossing our path, and exercising a constant, and because so, a powerful influence either upon our domestic comfort or discomfort, in proportion as they are well or ill done and attended to.

Men are but too apt to think lightly of the details of domestic or house work, and generally to understate them, till they actually persuade themselves that they are trifles of little importance in their daily life. But this arises chiefly from lack of thoughtful observation. He was a shrewd observer who remarked that much of the inconvenience and the loss of time, to say nothing of the trials of temper brought about by badly arranged houses and by the lack of various useful appliances and contrivances, arose from architects and builders who were apparently ignorant of their value; or who, if they were indeed aware of their existence, determined, like so many men, that they were but trifles, and treated them as such—that is, simply overlooked them. Certain it is that if the designers of but too many houses notorious for their lack either of convenience in plan or of contrivances had had a true conception of how they ministered to saving of time and to the doing of good work, they would have made their house plans very different indeed.

Limited Conception of Many of what constitutes Good House Planning.

The plan of a house seems to many to be a matter of great simplicity, and the points connected with it very easily decided upon and settled, if one may judge from the little attention paid to it, as evidenced in the numerous houses of different classes erected in all parts of the country. If carefully examined by one who has given some study to the subject, and more especially if this examination be followed up by an inquiry as to what those who do the daily work in them, think of them as tending to make that work more easily and completely done, it will be found that those who have designed them must have had a very limited conception of what the term plan, or the work of planning, involved.

The proper relation of one room to another, so that the convenience of those using them, the work of those who have to keep them in what is called "order," and of all the wide variety of work connected with the mere living of a family in the house, seems by this class of planners to have been totally overlooked. And yet how important this relation of the rooms one to another is, may be easily seen on a very slight consideration of what is really this daily life, and the duties and requirements of it. In a small house it may, for example, be thought by some to be but a very trifling matter if the kitchen be placed in such relation to the other and what are called the "living" rooms of the house, that a few yards of dark passage, or, worse still, a flight of steps, however short, are placed between them. "It is only a few more yards of passage, only a short flight of steps to be taken, and the work is done, taking only a few seconds, not even minutes. What is the use of making a fuss about such a trifle as this?" Such may be, and indeed often is, the way in which objections to such mal-arrangement in planning are met. But the very form of the excuse is the best possible proof that the whole issues or outcomes of the case have not been nor are considered. And it is just this lack of consideration as to the value of time which lies at the root of, or is the cause of, that want of it as to the importance of convenience.

Time lost and Fatigue incurred by Frequent Use of a Badly Arranged House.

For it is forgotten that, although in a single case it is no very great loss of time to traverse the few extra feet or even yards of a passage, or to run up a short flight of steps, yet it becomes a very different matter indeed when those yards or feet and that flight of steps are gone over many and many a time a day. We say that this truth is forgotten by those who make light of such a mal-arrangement in planning as we are now considering; it would be the more correct way of putting the point if we said that the true position of the matter is never thought of at all. Certainly, if thought of, it is deemed to be of such trifling importance that it can be very safely passed over. And we have known cases where, when the view of the matter as above named as to the aggregate large loss of time brought about by the constant repetition of small losses has been put before careless planners it has struck them with quite a sense of novelty. The poet has said that more evil is done in the world from lack of thought, than from any real wish or desire to do the evil. So it may be said that some planners of houses do in their arrangements cause the livers in them a vast deal of inconvenience, give them a great amount of bodily fatigue, and make them lose much valuable time, purely from lack of consideration of such points; not from any real indifference to the comfort and the convenience of those living in the houses. Indeed, as we have hinted, no one is more surprised than they themselves are when the true analysis of the case is put before them.

Some Practical Examples of Mal-Arrangement of House Apartments.

We have referred in general terms to the way in which the inconvenience in a house is created—namely, by badly arranging the rooms or apartments in relation to each other. But the point is of such importance, and bears so closely upon the comfort, the convenience, the time, and, as we shall presently show, upon the health of those by whom the work of our houses is carried on, that we deem a few examples culled from practical sources are likely to convey some useful suggestions to the young architect or builder. We have, for example, met with this arrangement in a detached suburban villa-cottage, or small villa. The house was of two stories, with a sunk flat, or what is called in the north of England a cellar floor. On the first floor the "entrance lobby," or "hall"—as it is termed somewhat grandiloquently in relation to small houses—the "drawing" and "dining" rooms, were placed. Also a very small room, termed appropriately enough the "sitting-room," seeing it was so very straitened in dimensions or floor surface that little else than sitting could be comfortably done in it, space for walking or moving about easily not being within its walls. The kitchen, which was of course also the living room of the domestic servant, was placed in the sunk or cellar floor, in that part of it immediately below the drawing-room. The kitchen in this position, and at this level, could not on the score of health be very seriously objected to as the habitual living room of the domestic,—or "slavey," so nicknamed with an irony not altogether uncalled for when we bear in mind the life which too many of our domestics live,—inasmuch as the walls of the cellar apartment were not strictly cellar walls—that is, surrounded on all sides by the soil of the site—but were partly above and partly below the general ground level. Ventilation, or a current of air through the kitchen, was therefore more easily obtainable than in the case of a purely cellar or sunk flat arrangement, lighted, as of necessity such places must be lighted, by a narrow—generally very narrow—cutting or well in front.

THE FACTORY OR MILL HAND AS A TECHNICAL WORKER.

THE ORGANIZATION, GENERAL DUTIES, AND SPECIAL WORK OF THE STAFF OF FACTORIES FOR THE PRODUCTION OF SPUN AND WOVEN GOODS—THAT IS, "YARN" AND "CLOTH"—AND THOSE CHIEFLY IN COTTON AND WOOL—GENERAL DESCRIPTION OF THE VARIOUS PROCESSES OF MANUFACTURE.

CHAPTER II.

WE concluded the first chapter by describing briefly the qualities of cottons used for different kinds of goods; and we might here state the average length of staple of the different kinds of cotton in the market, but as it would not tend much to give the reader a further knowledge of its use, we shall satisfy ourselves by giving the two extremes which we have seen tabulated, and which from our experience in the buying and using of cotton we believe to be trustworthy. Although we have not measured them with fractional accuracy, yet they may be accepted as correct; the shortest staple used for spinning or manufacturing being $\frac{23}{32}$nds of an inch, the longest 1½ inch long.

Explanation of the Term "Counts," such as "40^s."

The reader will have noticed the expression such as "40^s" in the paragraph above alluded to; the meaning of this may be briefly described now. All cotton "yarn," or as it is popularly called, "thread," is known for its various qualities by certain numbers, as the above, or 60^s or 150^s, or the like. The special number indicates that 40 or 60 or 150 "hanks" of yarn of a certain fineness go to the pound weight of yarn. The technical and trade points connected with "yarn hanks," making and packing up, selling, etc., etc., will be fully explained in due course. And before going into the actual details of the manufacture, and of the discipline and management of the different departments of the "mills" or "factories" where it is carried on, it will be as well to give here some general notice of that district of the kingdom which is on all hands admitted to be the grand seat of the cotton trade. To this we have already made incidental allusion in referring to Manchester, which is the centre of this busy district.

Brief Glance at the Great District of our Chief Textile Manufactures—Its Practical Suggestions.

Manchester is the depôt where goods of all kinds are deposited, to which manufactured articles of cotton in the various forms are sent as to a common market, and where they can be had, and if not in stock can be ordered, and very soon can be delivered—more easily, of course, in goods of a coarse than in those of a fine quality. As we proceed, we shall give reasons for the difference in time required for the preparation of fine over that of coarser materials. We say Manchester is the depôt for cotton manufactured goods. It is situated in a most central position, and therefore convenient to the surrounding spinning and manufacturing mills. It is encompassed on all its sides, or nearly so, by towns—themselves large and densely populated—which produce immense proportions of cotton goods in the form of yarn ready for any manufacturing purpose for which it is intended, and then, after being manufactured, that is, woven into cloth, to undergo a variety of manipulations—such, for instance, as bleaching, printing, dyeing, etc. Within the radius of twelve miles of Manchester it may be said that all the various processes here named are carried on in each or in most of the following towns. Manchester itself, considered merely as a manufacturing town, and not as the great centre to which the work of all the other towns gravitates, is noted for fine spinning (more fine than coarse spinning), manufacturing, dyeing, etc. It also contains every facility for making and fully preparing all the necessary machinery for spinning (making yarn), making cotton cloth (*i.e.* weaving), etc., etc. It has some fine engineering and millwright works, and also numerous machine works, which make machinery for every part of the world where cotton and other textile fibres are operated upon.

Taking next the town of Oldham, we find it to be most famous for its production of "32^s yarn," though it is somewhat renowned not only for spinning very coarse yarns, but for the quantity of them which it produces. From the common but somewhat expressive term used in the district, we may learn that Oldham has been, and is still, famous for its spinning of very coarse yarns, "three threads for an armful." Oldham being our largest spinning town in the kingdom, we must, of course, expect its powers of production to be very large. The finest yarn produced in that town is about "40^s." Cotton yarn is, as we have said, known for its various qualities by certain numbers—as "40^s" in the text; that is, 40 hanks of a certain fineness known as "40," go to the pound of finished yarn ready for the market. Oldham and its immediately outlying district is not confined to the spinning of threads, but it has some standing in the production of heavy manufactured goods, such as fustians and cotton velveteens. A great proportion of the cotton mills in Oldham are on the "limited liability principle." No town in Lancashire has what may be called such a mania in this direction of speculation as Oldham and its district, and therefore it is designated the great "emporium" for "limited liability companies." Oldham is favoured with one of the largest machine-making works not only of Lancashire, but of all the world, and that is now also a "limited liability company." The army of men and boys turning out from their work at meal-times (say dinner-time, and at 5.30 in the after noon, when the road is not only lined but filled with men and boys), is beyond description. There are other large machine-making works in the town.

Rochdale is, and has for long been, a noted town and district for co-operative cotton mills, but it bears in this respect no comparison to the town of Oldham and its immediate surroundings. Rochdale is a considerable town for cotton spinning and manufacturing; mostly for a coarse class of goods, heavy materials. It is possessed of some machine as well as of millwright and engineering works. Both these last trades stand in a good position in Lancashire and Yorkshire; many of the works are old-established concerns, which therefore have been well tested by the public. The machine makers in this town for certain classes of cotton, worsted and wool machinery, are second to none, and have held that position for a number of years. This town is not only famous for the above-named manufactories, their long standing, and the varieties of cotton spinning and manufacturing of cotton goods, and of iron works; but another branch of manufacturing is carried on—which, however, is more extensively met with in and about Halifax and other towns in Yorkshire—namely, that of "carpet manufacturing." It is not a leading class of manufacturing for Rochdale, but still there is one large firm which carries on that industry, and we believe the business has been successfully sustained for a long period, and stands in a solid position in the carpet market.

Between Manchester and Rochdale there are two other towns of some importance as cotton spinning and manufacturing places—Middleton and Heywood. In one of these towns, looms and other machinery for weaving (manufacturing) are constructed. Three miles from Heywood we come to the considerable town of Bury, where cotton spinning and manufacturing are carried on to a considerable extent, mostly in the coarser kind of goods. In and around the town many mills may be seen. This, like some other populous towns, has its large machinery-making works,—one especially, where every kind of machinery is made, from the boiler of a steam engine to the finest piece of machinery used in the spinning and manufacturing of cotton goods. If we proceed a distance of six miles we arrive at the important town of Bolton-le-Moors (commonly called Bolton). It is not renowned for its manufacturing of calicoes, fustians, velveteens, and printing-cloths; its manufacturing consisting in the making of sheetings. These sheetings are made from the coarsest material (or nearly so) that is spun, which is known by the name of "caddy sheets," sometimes designated as "Bolton sheets." There was a time when Bolton was famed for what is called "Bolton quilts," much used for vests. Not being fashionable at the present time, such cloth is little known. It was more commonly used for gentlemen's vests than for other purposes, was well known for its durability in wear and its cleanly appearance after being washed, and is a material in many respects well worthy of being again widely worn.

Bolton is better known, and has been from the commencement of the cotton spinning trade, for what are termed fine counts, *i.e.* fine yarns (fine threads). There are but about three mills at present engaged with this branch of the trade; the finest counts produced being 150^s to 300^s. The leading counts of yarn which this town boasts of now are from 40^s to 90^s, but the yarns generally named as "Bolton counts" range from 45^s to 60^s twist, designated "medium counts." The new mills in Bolton are noteworthy as regards the size of the structures, and in some cases for their elegance in design. The neighbourhood of this town abounds with "bleachers." No other town in Lancashire stands so high in this department of textile work. Bolton is by no means wanting in machine makers. Of millwrights and engineers it has almost more than its share. In machinery for cotton spinning it is celebrated for the making of the cotton machines known as "mules,"—hereafter described, and which are used for fine spinning. It has its forges probably to a greater number than any other town we have named.

Within about three miles of Bolton there are other places of large productive power for spinning and manufacturing. In returning towards Manchester we pass through, and adjacent to the main road, Mosesgate, Farnworth, Swinton, Pendleton, and Salford. At a distance of four miles from Manchester we arrive at Eccles and Patricroft, which have several mills. Leaving Manchester for Stockport, to the south, at a distance of six miles we come to a town not much renowned for its beauty—although for that of its environs few towns can claim so much — but none the less so for its production of yarns and cloth (calico). Stockport may be said to be the favoured town, as, if the first steam-power loom had not its birth actually there, it received those improvements which made it the effective machine it now is. These were due to a gentleman of the name of Horrocks; and, strange to say, his education had not been in any way connected with the Lancashire cotton trade. The productions of cotton yarns and calicoes in this town and in its immediate neighbourhood are of a coarse kind. Most of the mill buildings in and near the town are of an old stamp, better calculated for "throstle spinning" than for self-acting "mule spinning." There is much throstle spinning there. The river Mersey is lined with mills on its bank. Stockport is not noted for millwrights or machinists, but nevertheless it has its foundries and various small works where machinery can be repaired.

THE ORNAMENTAL DRAUGHTSMAN:

His Study and the Details of its Practice, chiefly in Relation to Technical Work in Manufacturing Design.

CHAPTER II.

First Lesson in the Drawing or the Copying of Straight Lines—Vertical Lines.

Here the pupil is expected to copy these five lines precisely and exactly as they are set down in fig. 1. A difficult task, undoubtedly; but also, we may say for his comfort, by no means an utterly hopeless one. Let the board before the pupil be on a table, raised to an angle of 30° if the pupil sits down; or if he stands up placed upon an easel, which he can easily make for himself. Then, with a pencil tolerably finely sharpened, let him commence operations.

Let him measure with the eye, quite calmly and deliberately, the length of the line *a b*, fig. 1, and try, with "all his mind set in his fingers," to make one like it. Then, after the same fashion, let him calculate the distance between *a b* and its right-hand neighbour *c d*. The pupil should then draw this second line in the same way, and proceed thus until he has managed to get through the whole figure. Now let him set the original and the copy together, and make a minute and searching comparison between them. *He will most likely discover immediately a difference in the sizes of the figures as wholes. The pupil has either estimated the length of the line a b incorrectly,* or the distance from *a* to *c* may be wrongly calculated, or very probably both of these faults are to be found in the drawing. Then let the pupil notice how very inaccurately he has mentally measured the amount of space between the lines individually. If he takes a pair of spring-dividers to test these distances, he will perhaps find the space between the first two lines greater by a fourth than that between the fourth and fifth. And let him observe, again, how much he has failed in attaining to the parallelism of the lines with the edge of his drawing-board or cartridge-sheet. The first one, for example, he discovers to be anything but strictly perpendicular. It has a somewhat decided tendency to incline a "leetle" too much either to right or left. He will notice, likewise, that instead of being parallel with each other, no two of the lines can with any amount of strictness be called so. For the meaning of the term parallel see the paper on "The Geometrical Draughtsman." In his copy the line *e f* may have some inclination towards *g h* or *c d*. In the original none of these faults exist: not only are the lines vertical, but they are parallel to one another. The pupil should here note that we use the term "vertical" with a purpose—a position of the line which is practically unvarying—making a special distinction, which is absolutely essential to be made, between this term and that known as perpendicular. For it is often the case, even with those who ought to know better, that these terms are used by them as being identical or meaning the same thing, which assuredly they do not. A line may be perpendicular to another line, yet that perpendicular line be horizontal—a statement which, although it may appear odd to some, is nevertheless absolutely true; just as a line may be perpendicular to another, and yet that other line may go in *any direction*. For a further exposition of this, and other like terms, the reader is again referred to the paper "The Geometrical Draughtsman."

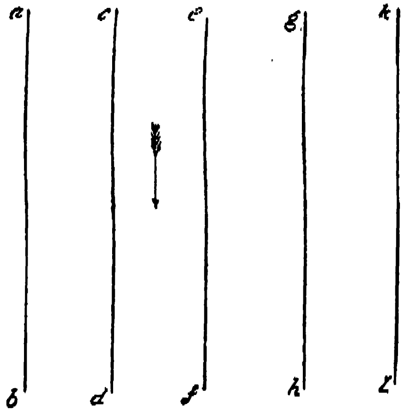


Fig. 1.

Let the draughtsman look, finally, at the unsteadiness and weakness of the whole five as *straight* lines: we may suppose that *a b* gives way in the centre; *c d* begins with a slight curve, straight in the centre, and curved again at the end; *e f* may be worse, and *g h* no better. And so on to the end of the lesson—wilfulness, inaccuracy, imperfection, from beginning to its end. Do not let the pupil at this point be guilty of throwing down his pencil and putting aside his drawing-board, either in disgust or vexation. Certainly, we admit that the examination of his first attempt has been most disheartening. It is hard enough to be conscious of weakness generally, without having all the particulars of that weakness thrust before one's eyes. Let him rest assured that the right fashion of *mending matters in this case is boldly to try again. He may take heart at being disheartened, for consciousness of weakness is really a step towards* strength—a somewhat paradoxical statement, the truth of which youth and inexperience have great difficulty in believing. Let the beginner remember that the thing he has set himself down to do demands, as we have all along told him, dogged determination, and purposeful, thorough, conquering labour. Excellence is attainable; but he may rest quite confident that an ocean of downheartedness will never fill one cup full of success. Let him start again, and yet again; let the extent of his wishes be the measure of his efforts, and triumph is certain.

Second Lesson in the Drawing or the Copying of Straight Lines—Horizontal Lines.

We pass on to fig. 2. The pupil will observe that its construction is exactly similar in all points to that of fig. 1, except that in this case the lines are *horizontal.* The instructions which were given for the drawing of fig. 1 apply to fig. 2, and a severe examination of this latter lesson is to be carried on, after the manner in which the former was criticized. The pupil should with all honesty and faithfulness test every line, until by repeated efforts his eye has become honest and faithful likewise, and his hand firm, powerful, and delicate. He will of course notice in these two figures the small arrows. These indicate the direction in which the lines are to be drawn. He may, in the first figure, draw the first three lines from top to bottom, the others may be drawn from bottom to top; and in fig. 2, in like manner, the top three lines from left to right, the lower two from right to left. Let him be careful, if he does no more, to do at least as much "as is set down for him," and in no wise neglect to practise the drawing of the figures after the directions given.

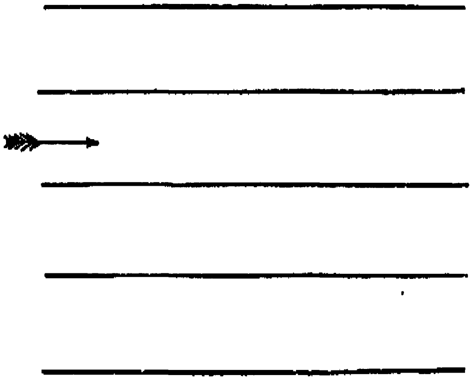


Fig. 2.

Third Lesson in the Drawing or the Copying of Straight Lines—Angular, Sloping or Oblique Lines.

We suppose now that the student has been grinding away at these figures, until he has attained to such power and truth of manipulation as will enable him to draw figs. 1 and 2, or subjects of precisely the same character, with some degree of certainty and accuracy. He has toiled away, mayhap, until his hand has been tired and his brain weary; but let him look at the result which he has attained. He can, as the result of his patient labour, draw a perpendicular line. He can likewise draw a horizontal line. He has a pretty correct notion of length. He can, to some extent at least, calculate the distance between two or more points. He has, in short, laid well and firmly the foundation of ornamental drawing, and the toil attending his efforts has been far more than compensated for by the increased power of his hand and eye. He should look at the fact that all the figures do not possess for him the slightest difficulty of imitation, and of course as much may be said of all the infinite combinations of straight lines.

We shall now take figs. 3 and 4. The pupil will observe that the lines in these figures are not parallel in either case with the edges of his drawing-board, but incline at an angle. This, however, will offer no great difficulty. He can draw a straight line, and the direction of that line is a matter of but subordinate consideration. Let not, however, the knowledge of his being able to do this have any influence towards lessening the concentration of his efforts towards the doing of the work of this special lesson well. Let him always keep clearly before him

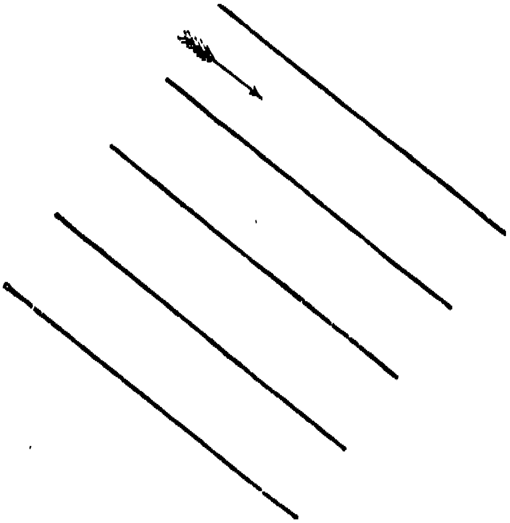


Fig. 3.

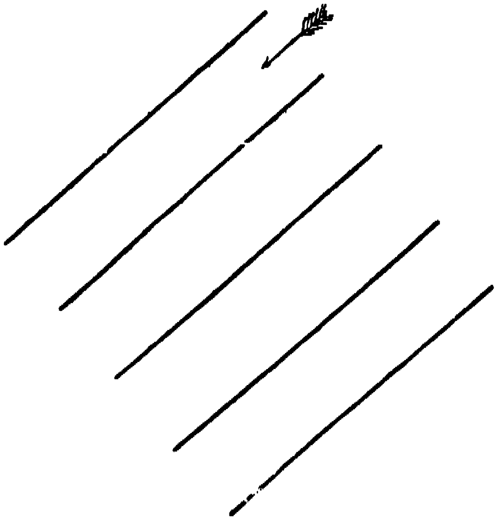


Fig. 4.

the fact that this work he is about is anything but easy work, and that his triumph will be measured by the constancy of his toil. He will carefully observe to draw the first three lines in figs. 3 and 4 in the direction of the downward-pointing arrows; the last two in either case *vice versâ.* Let him be sure, likewise, that the acuteness or obtuseness of the angles with the perpendicular edge of the drawing-board is correct. Let him carefully compare his copy with the original, and let him master every figure before he proceeds to the next.

Important Point to be considered by the Student at this Stage of his Elementary Work.

At this stage we would insist upon the pupil remembering this important consideration: that it is not the number of copies which he may finish which will indicate progress, but the manner in which they are finished. If he cannot firmly draw a straight line, let him work at it until he can,—there is nothing gained by doing a dozen copies in a careless or slovenly manner, but the great gain in being able to draw a straight line correctly in any direction, a student cannot overestimate, and the drawing or working power which it gives him is difficult also to exaggerate. Therefore if he master this, the first step, well, all that follows will become the easier. Yet do not let him for a moment think that we underrate the difficulties that are to be overcome in learning to draw curved lines; we only wish to impress this fact, that they will become easier from having mastered the difficulties of drawing straight ones. He will also see that th insistence on a habit of strict observation is layin down a basis on which his whole after studies depen He must remember that to educate the hand to dra and the eye to see any object correctly takes a lon time of very careful practice and observation.

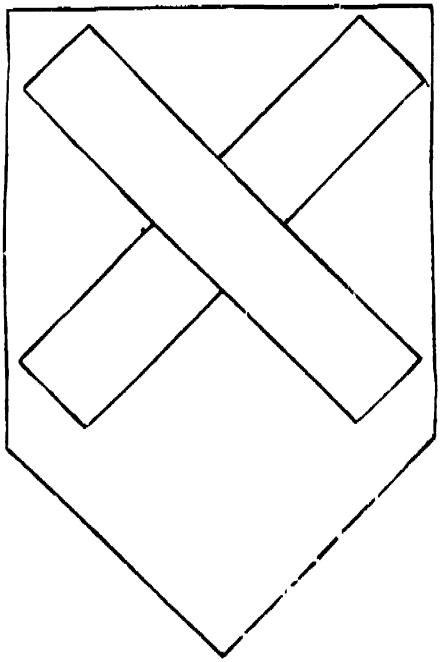


Fig. 5.

Fourth Lesson in the Drawing or the Copying of Straight Line —Combinations of the Classes of Lines of the Three Pr ceding Lessons.

A new combination involving points of practice c great importance to the pupil is illustrated in figs. and 6. In those all the elementary lines already give are combined in simple forms. Let the pupil dra fig. 5, keeping the drawing *in one position*, and chang the position of the hand to suit the different directions of the lines. The same remarks apply to fig. 6 The reader will have observed that a certain part c the above is *italicised*—" in one position." The poin here involved is one of considerable importance in the practice of drawing. It may be assumed as true tha while one draughtsman has a readier facility to draw a line in one direction than another draughtsman has, the latter may be able to draw with accuracy line in quite another direction. In either case the draughtsman will be tempted to place his drawing or copy in positions, as he proceeds with different parts of his drawing, which will enable him to follow that direction in which he can most easily draw the line. But, seeing that one of the results of his practice is that he should be able to draw with equal facility lines in different directions, this method of meeting the case is vitally wrong. He must place his copy precisely in the same position as shown in the figure— as in figs. 5 and 6—he is copying from. This is wha honest, conscientious work demands of him.

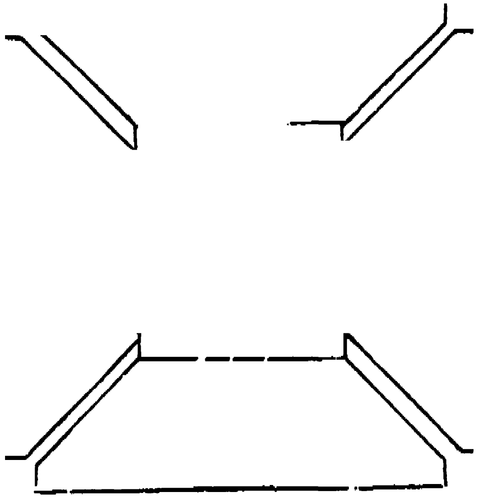


Fig. 6.

THE YOUNG ARCHITECT OR ENGINEER.

HIS STUDIES—OFFICE DUTIES—AND PRACTICAL WORK IN THE PREPARATION OF WORKING DRAWINGS, OF SPECIFICATIONS, AND CONTRACTS FOR WORK.

CHAPTER II.

Preliminary Sketches of the Work to be Done.

PRELIMINARY sketches are prepared by the architect and engineer with the object of ascertaining his client's intentions, and of studying how these can be arranged to the best advantage on the proposed site; they are generally drawn to a small scale, and are limited to plans and elevations: the latter are generally only rough, but effectively tinted pencil sketches.

It is very desirable that every point in connection with both plans and elevations should be thoroughly studied and discussed; definite instructions should be obtained before the contract drawings are commenced, and a survey of the site and its surroundings must be prepared and levels taken. A level, theodolite, poles, and a chain will be required. The use of these instruments, and surveying generally, will be separately described under the heading "Surveying."

When the site is in town it is frequently covered by old buildings, plans and sections of which are of course required, and are easily prepared with the aid of a sixty-six feet tape and a six-feet rod. The building should be first carefully examined, the relation of the different parts and the general plan and construction noted. Rough sketches in pencil must be made of each floor, showing all the architectural features, such as windows, doorways, chimney-breast recesses, columns, pilasters, steps, etc., and dimensions then taken—which can be done most rapidly when two men are engaged in taking dimensions and a third in booking them. Horizontal dimensions should, when possible, be taken from the outside face of the wall, and every effort made to obtain through measurements and diagonals. The vertical dimensions should be from floor to floor; and one should, if possible, be taken from the highest available point to the lowest, to serve as a check. When the preliminary sketches have been approved, and the survey and plans of the site prepared, the contract drawings can be commenced.

Contract Drawings,

as the name implies, are those on which the contract or agreement between the architect and the builder or contractor is based; they must completely illustrate every portion, internal and external, of the proposed new building, and as far as possible the entire construction. They are necessarily drawn to a small scale, generally to eight or four feet to one inch; occasionally other scales are used—six, twelve, or sixteen feet to an inch. The last of these is too small, but may be used for buildings covering large areas and containing little detail; and a "one-sixth" scale is a most objectionable one in practice, as the workpeople are unaccustomed to it, and not usually having it marked on their two-foot rules, are put to great inconvenience every time a dimension is required; serious errors are in consequence only too likely to occur. The time will no doubt come when scales similar in principle to those used on the Continent, based on a decimal system, will entirely supersede those now in use in this country. It is sometimes found desirable to include one or more drawings to a large scale, such as two feet to an inch, to further illustrate important portions of the building. The contract drawings include plans, elevations, and sections. The plans comprise block plan, plans of foundations, of every floor, of all elaborate ceilings, roof timbers, and finished roof plan. The sections are longitudinal and transverse; their number must necessarily depend on the size and character of the building; they must illustrate the interior of every large room, every difference of level, all staircases, halls, corridors, the main roof construction, and any special feature of the interior. The elevations must show every portion of the exterior, both above and below the ground level; the portion below is generally dotted.

Before describing the drawings in detail, a few words on their preparation may not be out of place. They are either drawn on sheets of paper damped with a sponge and glued round the edges to drawing-boards and allowed to dry and stretch as already described, or on paper mounted on calico. The number and general dimensions of the plans, elevations and sections must be ascertained and roughly plotted on the sheets of paper, one or more being drawn on each, as space will allow, with a wide uniform margin all round for the border-line, title, number, and scale. The first drawing is:—

The Block Plan

of a building, on which the proposed buildings are shown only in outline, together with the general surroundings and approaches; thus, if it is situated in town, the streets in front, at the sides and at the back, or the adjoining property, should be included; if the site is in the country, the approaches from the nearest road, and all surrounding features that may be necessary to accurately fix the position of the building, or may in any way influence the plan, must be shown. The drains and their connection with the nearest sewer or cesspool are usually drawn on this plan, as well as all out-buildings, yards, areas, enclosures, terraces, and grounds. The scale of the block plan is generally smaller than that used for the other drawings; it may be considered a survey rather than an architectural drawing. The cardinal points are usually included, and any further information incidental to the site.

The Plan of Foundations

is frequently included among the contract drawings; many architects, however, in order to save time, make the plan of the lowest floor serve in its stead. If the foundations are very extensive, a carefully figured plan of them is a great convenience to the contractor and to the clerk of the works, and should never be omitted. On this plan all the external and internal walls, foundations of columns, piers, machinery, hoists, engine beds, boiler flues, areas, etc., must be distinctly shown, and if they are on different levels small sections should be added in the margin, carefully figured from any available fixed point on or near the site. For this purpose a doorstep, window-sill, string-course, or an iron pin driven firmly into the ground where it is not liable to interference during the progress of the works, may be used. The distances between the walls, piers, etc., the width of all openings and arches, should be carefully figured as far as possible from centre lines, and the thickness of all the walls should, if built of brick, be stated in bricks thus, <— 1½ bricks —>. On the small sections the radius of each arch must be figured, and the centre from which it is struck distinctly marked. Concrete, puddle, piles, flagging, required by the nature of the ground to make sound foundations, must be shown, figured and distinguished by suitable tints.

The Basement or Cellar Plan of a Building

is that of the floor built wholly or partly below the street or ground level; in many buildings erected on valuable sites a sub-basement is placed below (in some cases several). The height of the cellar above the ground depends, of course, on the use to which the building above is devoted: if the ground floor is to be formed into shops, or used for any purpose that necessitates an approach by only one or two steps, the cellar must be entirely below the ground level, and lighted by areas or deck-lights; but when the architect is not thus bound, it is advisable to build it a third, and if possible half, of its height out of the ground. Buildings intended for domestic purposes should invariably be cellared throughout, even if the space cannot be used for any useful purpose, as it adds, if well ventilated, to the dryness and warmth of the floors above. In warehouses the engines, presses, and all heavy machinery are invariably placed on the lowest floor, as the vibrations would in course of time injure the building if they were placed in one of the upper stories; and as portion of the basement is generally used for the storage of the heavier goods, it is usual to build it with as large a window area as possible above the street level. The contract drawings of a warehouse should therefore include a sub-basement plan entirely below the street level, in which the boilers, engines, presses, and any other machinery required can be placed, and a basement plan having window-sills level with the street pavement, if possible, for the storage of heavy goods. The position of the boilers and machinery, engines and shafting, on the plan must always be carefully studied and distinctly drawn, as they should of course be so placed that they can be easily removed when worn out. Instances have been known to occur when it has been necessary to take down portion of a building in order to remove an old boiler and insert a new one, through the neglect on the part of the architect of this very obvious foresight. Machinery of every description should invariably be drawn on the plan with sufficient space for the workpeople to approach it from every side. Boilers would be useless without plenty of space in front, and if the position of the coal stores and means for removing the ashes were not carefully planned, great loss of time and unnecessary labour would be caused. When the basement or sub-basement floor is boarded, short air flues, protected by cast-iron grids, must be shown on the plans, extending from below the floor-boards to the exterior of the building, to prevent the air between the joists from becoming stagnant. Shafts or flues must be carried above the roof, to carry off vitiated air, and be drawn both on the basement plan and on those of all the upper floors. If the architect omit these details, the property of his clients will soon become subject to dry rot. On the plans of these floors, both the internal and external walls are made considerably thicker than on the plans of the floors above—more especially the latter, which should, in the case of dwelling-houses, be surrounded by a continuous area eighteen inches wide, covered with a cast-iron grating as a protection against damp. Basement plans are not always arranged to provide for storage and machinery; occasionally the architect is expected to provide accommodation for many other purposes, more especially in buildings erected in large towns. For instance, dining and billiard-rooms are frequently placed below the street level; large fire-proof safes and muniment-rooms must be shown on the basement plans of warehouses and banks. The small theatre in the basement of the "Criterion" in London, the boys' reading-room under one of the free libraries in Manchester, and school-rooms under churches and chapels, are examples of basement floors made to serve special purposes.

The above remarks will convey to the young architect a fair idea of the points to which he should direct his attention in connection with the plans of cellars or basements of the different classes of buildings named. As a rule too frequently with many, this part of the structural arrangements has but little attention given to it, and in many "sets of plans" so called, its plan is altogether absent.

THE ALKALI MAKER AND HIS TECHNICAL WORK.

INDUSTRIAL IMPORTANCE OF HIS PRODUCTS—THE MAKING OF SULPHURIC ACID, SODA ASH, CAUSTIC SODA, SODA CRYSTALS, USED IN A WIDE VARIETY OF PROCESSES.

CHAPTER I.

Introductory.

SIXTY years ago the alkali maker depended for his raw material on the ashes of plants; sea weeds when burned yielded the alkali called soda, while the ashes of land plants yielded the alkali potash. Since that time—that is to say, since 1823—the ingenious process discovered by a French apothecary named Le Blanc has been introduced all over the world, but especially in England, for the manufacture of soda from common salt. This invention dates from the year 1792, and the process was in work in France two years later; but the inventor did not reap the fruit of his labours, and after a life of much suffering died in a French workhouse. This, or a like, is the two frequent fate of the benefactors of mankind, as the annals of invention and discovery but too painfully show.

Materials used in the Process.

The details of the process as laid down by Le Blanc differ in no important respect from that at present in use—the materials required, and even their amount, being precisely the same. These materials are :—

Sulphuric acid (oil of vitriol),
Sodium chloride (common salt),
Carbonate of lime (limestone, chalk), and
Coal.

The alkali maker soon found it advantageous to make his own vitriol, and as in every large alkali works the vitriol plant is worked beside the alkali plant, we begin with a description of this important manufacture.

Manufacture of Sulphuric Acid.

Occurrence.—Sulphuric acid occasionally occurs in the free state in nature. This is particularly the case in volcanic neighbourhoods, such as Iceland, the Andes, New Grenada, and Java, where it is doubtless produced by the oxidation of sulphur and its compounds. Although the amount of acid formed in this way is sometimes large, amounting according to Boussingault in one case to 15,000 tons per annum, it is not possible to utilise such sources for the economic production of the acid.

History.—Sulphuric acid was probably known to Geber, but its preparation is first described by Basil Valentine, and still more fully by Gerard Dorneas in 1590. It was made at that time by distilling sulphate of iron (green vitriol)—a method still employed for preparing the strong fuming "variety" called Nordhausen sulphuric acid. Its manufacture from sulphur is of English origin, and is due to Dr. Ward, who patented a process for its production, by heating a mixture of sulphur and nitre in large glass vessels containing a little water to dissolve the sulphuric acid formed. This acid was known as oil of vitriol "made by the bell," and was thus distinguished from that made from green vitriol. The glass "bell" was soon replaced by leaden chambers, at the suggestion of Dr. Roebuck, of Birmingham, who, in 1749 erected large works at Prestonpans in Scotland, where the manufacture is still carried on. Since then the operation has been chiefly improved by increasing the size of the chambers, and by carrying on the process continuously.

Theory of the Manufacture of Sulphuric Acid.

The materials now used for the manufacture of sulphuric acid are as follows :—

Sulphur, or iron pyrites, yielding sulphur dioxide, when burned.
Chili saltpetre (sodium nitrate), yielding nitric acid when treated with sulphuric acid.
Air as a source of oxygen.
Water in the form of steam.

When these four products—namely, sulphur dioxide, nitric acid, air, and steam—are brought together, sulphuric acid results, but the precise character of the reaction has given rise to much discussion, and even now can only be approximately explained. Briefly stated, its general nature is as follows:—The sulphur dioxide takes up oxygen from the nitric acid, thereby producing various oxides of nitrogen and sulphuric acid. These oxides of nitrogen are also capable of oxidizing sulphur dioxide, and in presence of steam sulphuric acid is formed, and ultimately nitric oxide, which, however, is incapable of oxidizing sulphur dioxide. But nitric oxide is readily converted by the oxygen of the air into higher oxides, which again effect the oxidation of further quantities of sulphur dioxide, and by the recurrence of these reactions a continuous process is established which theoretically ought to go on so long as fresh quantities of sulphur dioxide, steam and air are admitted to the chamber. Of course this is practically unattainable, owing to leakage, dilution with the nitrogen of the air and other causes, and hence it is necessary to add from time to time fresh quantities of nitric acid as well.

Reactions in the Process of Sulphuric Acid Making.

The reactions may be expressed by the following chemical equations :—

(*a*) Nitric acid ($2\ HNO_3$) + Sulphur dioxide (SO_2) = Sulphuric acid (H_2SO_4) + Nitrogen tetroxide (N_2O_4).
(*b*) Nitrogen tetroxide (N_2O_4) + Sulphur dioxide (SO_2) + Water (H_2O) = Sulphuric acid (H_2SO_4 + Nitrogen trioxide (N_2O_3).
(*c*) Nitrogen trioxide (N_2O_3) + Sulphur dioxide (SO_2) + Water (H_2O) = Sulphuric acid (H_2SO_4) + Nitric oxide (N_2O_2).
(*d*) Nitric oxide (N_2O_2) + Oxygen (O_2) *from the air* = Nitrogen tetroxide (N_2O_4).

Thus it will be seen that equations *a*, *b* and *c* all result in the formation of sulphuric acid and of one of the oxides of nitrogen capable of oxidizing sulphur dioxide, with the exception of nitric oxide. This, however, is easily converted again into a higher oxide by mere contact with the oxygen of the air (equation *d*), and if more sulphur dioxide and water be added, the reaction represented in equation *b* is repeated, and the process thus becomes continuous. During these reactions a solid crystalline compound frequently forms, called "leaden chamber crystals"; as it easily decomposes on addition of water, yielding sulphuric acid and nitrogen trioxide, its formation does not interfere with the process. Its constitution is represented by the formula $\mathrm{SO}_2{}^{\mathrm{HO}}_{\mathrm{NO}_2}$, while sulphuric acid is $\mathrm{SO}_2{}^{\mathrm{HO}}_{\mathrm{HO}}$. On addition of water (or steam) the following reaction occurs:—

Leaden chamber crystals ($2\,\mathrm{SO}_2{}^{\mathrm{HO}}_{\mathrm{NO}_2}$) + Water ($\mathrm{H_2O}$) = Sulphuric acid ($\mathrm{SO}_2{}^{\mathrm{HO}}_{\mathrm{HO}}$) + Nitrogen trioxide ($\mathrm{N_2O_3}$).

Apparatus for carrying out the Processes described in last paragraph.—Making of Sulphuric Acid on the Small Scale.

On the small scale all these processes may be carried out (including the formation of the chamber crystals) by means of the apparatus represented in fig. 1.

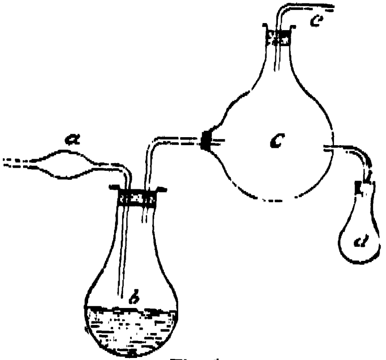


Fig. 1.

In the bulb tube *a* sulphur is heated by means of a Bunsen lamp, and the sulphur dioxide produced is led into the flask *b*, where a mixture of nitre and sulphuric acid is heated so as to yield nitric acid; the gases then pass into the large globe *c*, where the various reactions take place, aided by steam obtained by boiling water in the flask *d*. The supply of air enters at the open mouth of the tube *a*, and is kept up by attaching the tube *e* to an aspirator. If the water in *d* is not heated at the beginning of the operation, the leaden chamber crystals form in *c*, but are soon removed on allowing steam to pass into the globe.

On the large scale we have an exact counterpart of this miniature apparatus: the globe *c* is replaced by huge leaden chambers, the bulb tube *a* by pyrites burners or kilns, the flask *b* by iron pots containing nitre and sulphuric acid, the flask *d* by ordinary boilers, and the aspirator is represented by the chimney of the works.

Kilns or Furnaces for Burning or Calcining the Pyrites used in the Making of Sulphuric Acid.

The pyrites used for the manufacture of sulphuric acid usually contains from 30 to 48 per cent. of sulphur, about 40 per cent. of iron, and the remainder is made up of silica, copper, arsenic, etc. It is burned in a kiln which is kept frequently supplied with fresh quantities of the ore, while the spent or "burnt ore" is removed and is usually sold for the sake of the copper it contains. Various forms of kiln are in use, but there is not much difference in their construction. Usually they are built of brick, cased with iron plates and bound with iron rods. The interior is lined with fire-brick, and the bed consists of loose fire-bars, while the doors and other openings are of iron. Fig. 2 gives a rough sketch—a diagram, merely, not in any sense a working drawing (see the paper entitled "The Furnace Designer and Builder")—of the pyrites burner or furnace: *a*, *a*, are sliding doors for nitre pots; *b*, *b*, doors through which sulphur ore is admitted; *c*, *c*, sliding doors through which the ore is raked from time to time; *d*, *d*, iron doors closing in fire-bars and ashpit. Fig. 3 is a section: *e*, *e*, nitre pots; *f*, *f*, fire-bars on which sulphur ore rests; *g*, flue to vitriol chambers.

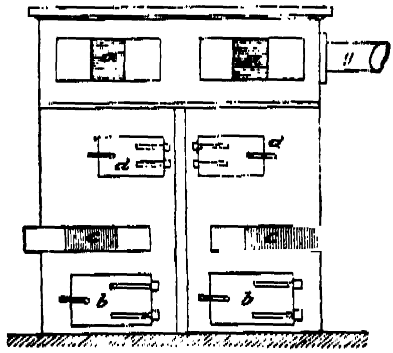


Fig. 2.

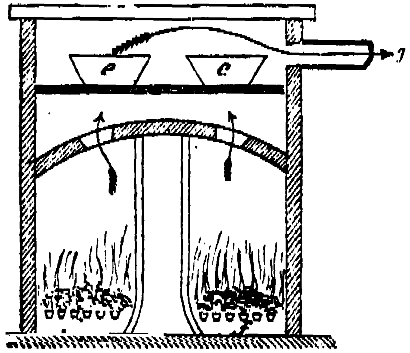


Fig. 3.

Connected with the pyrites kilns are small chambers in which iron pots containing a mixture of nitre and sulphuric acid are placed so as to generate nitric acid. Chili saltpetre (nitrate of soda) is usually employed, the proper quantity of vitriol added, and the "nitre pot" thus charged is sufficiently heated by the pyrites kiln. The nitric acid, passing off, mingles with the sulphur dioxide, and both gases, as well as the products of their reaction on each other, are led by the same flue into the leaden chamber.

The Leaden Chambers used in the Manufacture of Sulphuric Acid.

The chambers are usually placed above the kilns, *e, e*, fig. 4, and the floor thus forms a roof beneath which such operations as the breaking up and sorting of the sulphur ore are conveniently conducted. On this floor, *h h*, fig. 4, sheet lead (of about 10 lb. to the square foot) is spread so as to cover the entire area, and the sides are bent up about a foot, so as to form a huge reservoir for the acid. Above this reservoir a wooden framework is constructed to support the walls and roof of the chamber, which are made of sheet lead (about 5 lb. to the square foot), and fastened to the framework by leaden straps, soldered to the chamber and nailed to the wood. In this way a vast leaden room is constructed (sometimes having a capacity of 40,000 cubic feet), while the floor consists of a huge shallow leaden tank, as *h h*, fig. 4, in which the acid is collected and stored. The sides are not attached to this tank, but simply hang close to the turned up sides, as at *c*, and the escape of gases from the chamber is prevented by the layer of acid, which forms a perfectly tight lute.

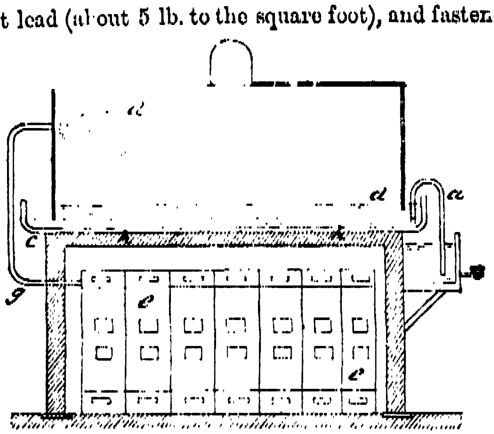


Fig. 4

The gases are admitted to the chamber *d d*, fig. 4, from the kilns *e, e*, by an iron pipe *g*, placed rather more than half way up, and they are led off to another chamber by a pipe placed low down in the chamber, and at a distance from the first pipe. In the second chamber the condensation of the acid is still further carried on.

The dilute acid thus produced is syphoned off into a tank from time to time (*a*), and needs only to be further concentrated by evaporation in shallow pans, lined with lead.

Recovery of the Nitrous Fumes created by the Process of Sulphuric Acid Making.

If the manufacture were conducted as already described, large quantities of nitrous fumes would pass up the chimney, and not only be lost to the manufacturers, but would pollute the air to an intolerable extent. To obviate this, Gay Lussac proposed to absorb these fumes with strong sulphuric acid, and to recover them by simply diluting this acid. For this purpose two towers are employed, usually about fifty feet high, one called the Gay Lussac or absorbing column, the other the "Glover" (for this term see the "Technical Dictionary") or denitrating column. The Gay Lussac column is made of strong sheet lead, and is packed with pieces of coke, over which strong sulphuric acid is allowed to trickle. The chamber gases enter at the lower portion of the tower, and in passing upwards yield the nitrous fumes to the sulphuric acid, which is collected in a cistern at the foot of the tower, and is then known as nitrated sulphuric acid. A cistern at the top supplies acid of specific gravity about 1·75, and another cistern at the foot receives the nitrated acid, which is afterwards pumped to the top of the Glover's tower or denitrating column, which is packed with flints instead of coke. Two cisterns, *a, a* (fig. 5), are arranged at the top, one containing chamber acid and the other nitrated acid, and when these are mixed together in the tower, the latter parts with its nitrous fumes. At the lower end of the tower the sulphur dioxide is admitted direct from the pyrites burners, and meeting the liberated nitrous fumes, carries them away to the chamber where the reaction is still further developed. At the same time the heat of the gases from the kilns serves to evaporate the diluted acid, which is considerably strengthened by the time it reaches the cistern *b* at the foot of the tower; indeed, in some works no further process of concentration is adopted.

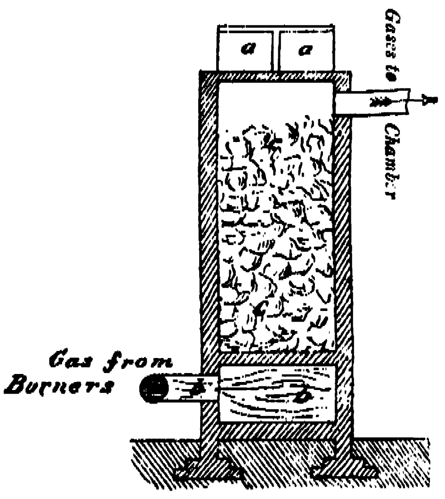


Fig. 5.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER I.

Introductory.

If the reader will turn to the illustrations under the head of "The Ornamental Draughtsman," take even but a brief glance at them, and study only slightly the instructions which accompany them; and if thereafter he will turn to those illustrations given under the heads of such constructive subjects as Carpentry, Joinery, or Mechanism, he will readily see, as the result of this comparative observation, that there is a marked and distinct difference between the styles of these, or methods by which they must be drawn or delineated, and that there must be also a difference between the principles which guide the practice of the ornamental and those which dictate the work of the building or architectural and machine or engineering draughtsman. The ornamental draughtsman in the execution of his work has nothing to depend upon but the accuracy of his eye to appreciate and take in the conception of form and to estimate distances and dimensions, and the skill and dexterity of his hand to give position to the lines and curves making up the object which he has to draw or copy. In none of his work has he the aid or help of any mechanical appliance or instrument. If he has a straight line to draw of a given length, he must trust to the steadiness of his hand to draw it as straight as he can; and to the eye also he has to trust in deciding the length of the line. So with curved lines he has still to trust to his eye; and on the fact as to whether his eye is educated or not depends the circumstance as to whether he makes an accurate copy or representation of the curved line as it really is, or only that which he supposes it to be. This distinction is worthy of being noted here, for although very contrary indeed to the popular notion which determines or supposes that if a man looks at an object he therefore sees it, the remark of one of our ablest thinkers and observers is profoundly true, that the eye only sees what it brings the power to see. Or, in other words, the eye must be educated to see things properly before they can be seen accurately—not merely as one supposes that he sees them. The remark has its practical application to the work of the building and the machine, as well as to that of the ornamental draughtsman.

For although, as may have been gathered from the brief comparative view we have recommended the reader to take, and as will be presently more fully seen, the building and the machine draughtsman is aided and guided in his work by special appliances and precise rules and methods of operation, it is quite a mistake to suppose that the education of the eye is not of importance practically to them both. This should be so trained that it can take in accurate conceptions of form and of distances and dimensions, although it may not be demanded of them that they should have all the manipulative dexterity of the ornamental draughtsman to put the work of the eye on record upon paper. The reader will see, as he proceeds, that this education of the eye will be of great practical value, even to the machine draughtsman, who is but seldom called upon to do any work which can be dignified with the name of "ornamental drawing." But to the building draughtsman it is absolutely essential, as one department of his work is as much purely ornamental as that of the draughtsman whose speciality is the drawing and designing of forms purely ornamental as well as of natural or conventional forms.

Distinction between the Work of the Building and Machine and that of the Ornamental Draughtsman.

Unlike the work of the ornamental draughtsman, that of the builder or architect and the machinist or engineer, so far as working drawings are concerned, is performed by the aid of appliances and instruments more or less numerous. By these straight lines are drawn and curved ones described with all accuracy and fineness as regards direction and style, and distances are measured and transferred and dimensions taken and laid down on the paper with absolute practical accuracy and precision. Nothing, so far as those points are concerned, is to be left to the decision of the eye, however accurately it may be able to do its work; nothing to the guidance of the hand only, however delicate may be its manipulative dexterity. The work is done solely by the use of instruments delicately adjusted, and by appliances accurately constructed.

The Special Class of Drawing required by the Builder or Machinist, frequently termed "Mechanical Drawing"—Reason why this Term is not here adopted.

Hence the name of "mechanical drawing" has been given to the work of the architectural and engineering draughtsman; not wholly, or correctly viewed, because the work is supposed to be connected with machines and machinery only. For if so, architectural work would be excluded, which *per se* has little or nothing to do with machines or machinery, however much they may be employed to aid the constructive work of the builder (see "The Stone Mason"). If applied to it at all, the term "mechanical drawing" should be understood to convey the idea that the work of the building, machine, or engineering draughtsman is performed by the aid of instruments and appliances which, in their nature and construction, are purely "mechanical." When the term "mechanical drawing" is applied, or supposed to be applied, to the drawing of machinery only, it is far too limited in its scope. Hence the reason why we prefer to use the wider term which embraces the work both of the builder and machinist in preparing their working drawings, in which the principles dictating the practice are common to both.

Proposed Mode of Treatment of the Subject.

In presenting what instructions we have to give under our title, we propose to divide, so far as may be practicable, the work of the building from that of the machine draughtsman, giving those constructions and forms which are specially applicable to the practical work of each under separate chapters or divisions—preceding those by illustrations and methods or rules common to the practice of both. As we have already hinted, there is, however, this difference between the practice of the two classes: that whilst the work of the machine or engineering draughtsman may be said to be wholly done by the aid of instruments and appliances, that of the building or architectural draughtsman comes under *two* classes or divisions. The first of these is the same in principle as that of the machine or engineering draughtsman, being performed by those appliances and instruments; the second that in which the principles of ornamental drawing are involved, the work being that of design purely. It is obvious that with this latter class of drawing the present series of chapters has nothing to do; the building or architectural draughtsman who desires to study this branch of his work must go to the series of papers given under the title of "The Ornamental Draughtsman," the instructions there given being strictly applicable to this department of his work.

The "Copying" of Building or Architectural and of Machine or Engineering Drawings.

Having stated this by way of explanation of the difference between the two departments—building or architectural, and machine or engineering drawing — we now proceed to give examples of work in each, preceding these, as we have said, by explanation and illustrations of work common to both. In what we have to give on the subject of our paper considered as a whole, we do not propose to take up much space on the subject of mere "copying" of drawings. What we give under this head will be purely elementary, and by consequence will be comprised in a comparatively brief series of sentences, and illustrated by comparatively few diagrams. Nor does much require to be said on this subject of copying. Once the general principles upon which it is based are understood, it rests with the draughtsman to give that steady and patient practice by which alone a ready facility to *copy* drawings, however complicated, can be acquired. What the technical student requires, in as wide a variety as he can obtain, is a series of constructions practically useful in the actual practice of architectural design, building construction, or engineering work, and in machine designing and making. And it should be here taken note of, that the mere work of setting out those various parts which are thus of such practical value will constitute in itself a wide range of practice in "copying." The more the draughtsman adds to the number of constructions or problems of the kind above alluded to, the more readily will he acquire the art of "copying" such drawings as may be presented to him in his office or in the practical work of his study of the art. (See the paper entitled "The Young Architect or Engineer, His Studies, Office Duties and Practical Work."

A facility to copy correctly is beyond all doubt useful to the draughtsman,—in point of fact, he cannot dispense with it; but it is a mistake to consider that copying alone constitutes the work of the draughtsman.

Copying of Drawings—Some Remarks on the Methods by which it is too frequently Practised.

It is, however, none the less a fact that with some teachers of what is popularly called mechanical drawing, the ability to copy drawings which may be placed before their pupils composes the whole of their practice. This, however, may be said to apply more particularly to ordinary schools, although not seldom is the mistake made to some extent in those which claim to possess a higher status, as in some technical classes or schools. This system would not be so prolific of untoward, if not positively evil results, if the task of mere "copying" of the drawings allotted to pupils as the one and only feature of mechanical drawing so called was in all cases performed on correct or common-sense principles. But the pupil is but too frequently set to a drawing and told to copy it, and this he does as best he can; and if failing to understand how it can be copied, the teacher may practically show him some way in which the various parts of the drawing placed before the pupil may be in some fashion or other copied. But in many cases what method may be shown the pupil is in itself anything but methodical. The pupil in such cases is not able to comprehend the drawing or subject as a whole. Of the machine, he has no explanation given him as to what are the characteristics of the worl. to be done by it, and how those characteristics of machinal necessity give birth, as it were, to the various parts, and the way in which they are arranged in relation to one another. If the pupil were made to understand this relation he might, and if of even average intelligence he would, be led to see more or less clearly how that relation would indicate or dictate to him a method of copying the drawing of the machine before him, which would from its common-sense fashion have some claim to be considered methodical. In but too many cases the pupil is left to go blundering on, beginning at one part, and that without any consideration as to whether that was or was not the right part which he ought to begin with.

He next leaves this part, being probably soon tired of what he calls the sameness of the work, and urged by a desire for change goes to another and perhaps a totally different part. All relationship of one part of the design to another part thus wholly vanishes, or we should rather say has had from the very beginning of his work no existence. Even viewing the different parts which he takes thus in hand to copy as in themselves distinct copies, he has but too seldom imparted to him a correct notion of how that part should be copied. Even in but a single part, he will just as likely as not begin to copy at a point which is the very last he should start with; and this aimless and objectless way of working is almost certain to bring about errors. And an error at the first starting becomes, as the drawing or copying is proceeded with, greater and greater, till the copy as a whole when said to be finished is such that the work had better never have been attempted, so erroneous is it as a whole. The pupil, moreover, having no fixed principle upon which he does his work, is just as likely to attain the same end of erroneous work in the next drawing he is set to copy as not. And thus it comes about that continued practice, in place of making his work more and more perfect, has in fact precisely the opposite result. It is practically but folly for one to have a facility in going quickly over ground if the direction is one in which he ought not to go at all.

The True Principle underlying all Good Practice in the "Copying" of Building and Machine Drawings.

Now, if a drawing, no matter whether it be architectural or engineering, be well thought out—that is if the design be good (and the remark in great measure applies to all drawings, even those badly designed)—when closely examined, it will be seen that its parts are grouped round a central point; and even when taken in divisions and each one considered separately, it will be seen that it has a central point round which its constituent parts group themselves, and to which they are subordinated. We have, in a tree, a graphic illustration of this essential truth in all drawings of construction. This, if we analyse it, is made up of a series of branches. Each branch has its offshoots in lesser branches, which again have each their offshoots, until we come to the tender twigs, almost hairlike in dimensions, and these again have their offshoots. We have thus a series—and in a large tree their number is, so to say, infinite or numberless—of parts, each of which is dominated, to use a graphic expression, by a central point round which its minor members group themselves; and all those parts are again dominated by or subordinated to the great central point of all—namely, the trunk or bole of the tree.

Now, the lesson to be learnt from what we have here stated should be obvious. And yet that it is not so, or at least that the principle which our remarks and example involve has not been thought of by many, even by some who profess to teach mechanical drawing so called, is obvious enough when we consider the way in which many pupils are turned out from some classes as finished or educated draughtsmen; which a practical man, who knows what drawing really is, very soon finds out that they are not—if they be sent to his drawing office or his works. We have said that the lesson which our remarks carry with them is obvious enough. And it may be stated in two sentences. If the drawing to be copied as a whole be carefully considered, with a view to discern its object, it will be found, as we have said, that however numerous the groups of parts making up the whole, each group has its central or dominating point, and all are dominated by the chief or central point of the whole design. And further—and this is the point so far as the copyist is concerned—that if he can get a series of central points or lines, and the exact position of those on the paper on which he is to make his copy be found, he is likely to copy his drawing with greater accuracy than if he begins at any single point and goes floundering on as best he can to find other points in relation to the first. The position of the central lines in the original being clearly and decidedly defined, by accurately adjusting them and transferring them to his own paper on which the copy is to be made, the draughtsman has not only a series of lines—branches, so to say, going back to our example of a tree—from which he can measure the distances of its subordinate parts, but they afford a series of datum or leading lines, by which he can test the accuracy of their position in relation not only to one another, but to the great central line of the whole design—the bole or trunk of the tree in the example we have taken to illustrate this essential principle of drawing and copying. How this central-line principle is applied to and carried out in not merely the copying but the designing of architectural and engineering subjects will be seen as we proceed.

The Instruments and Appliances used by the Building and Machine Draughtsman.

Lessons and examples connected with what is so often called mechanical drawing—a term so loose and vague that we have, as already explained, determined not to adopt it in our paper—are generally preceded by descriptions and illustrations of the various kinds of instruments employed in the work of drawing, whether that be of merely copying or of designing. This we do not consider necessary to give here.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

The Technical Points connected with the Varieties or Breeds of Cattle—Their Breeding, Rearing, Feeding, and General Management for the Production of Butchers' Meat and of Dairy Produce.

CHAPTER II.

At the conclusion of the first chapter, we stated that increased national prosperity had increased the demand for farm produce; this obtained to such an extent, that the same principle of subdivision of labour and of commercial and trade interests which led to the severance of what formed special and distinct trades in other branches of industry into two or more divisions, each of which in turn gave rise to a new trade, led also to the subdivision of the special, and for a long time the single work of the farmer into several branches. No doubt, circumstances of locality, soil, and climate in course of time dictated also this subdivision; but the general result is that now we have farming practically carried on under separate classes. We thus have the sheep farmer, the dairy farmer, the town or suburban farmer; and lastly, not to go into other finer subdivisions, and cognate to our present remarks, the breeder and feeder of live stock designed for the butcher—in other words, the grazier. The details connected with what may be termed general farming will all be found treated of in the series of papers entitled "The Farmer as a Technical Workman," while those connected with the last named of them, "The Grazier," will be taken up in the present series, the reason for giving separate place to which in our pages will, we trust, be now obvious to the reader.

The Three Classes of Live Stock bred, reared and fattened for the Production of Butchers' Meat—Fattening Cattle—The British pre-eminently the Best Breeders of Cattle.

Of the three classes of farm live stock, bred and reared for the butcher or as producers of what is known as animal food or butchers' meat, the fattening cattle, sheep and pigs, the first-named ranks highest in practical importance, and takes the first place in the estimation and the work of the grazier. It is almost impossible to exaggerate the importance of the work done by the grazier (thus to be treated of as a separate branch of the work of the British farmer) in increasing the value of breeding and feeding cattle. In the production of mere numbers or large herds of "stock"—which name, by the way, is almost universally understood to apply to cattle only—our farmers are of course excelled by those of other countries, with their vast extent of grazing or feeding grounds, as on the continents of Europe and America. But for the excellence of our breeds, which embrace every point which constitutes the value of fattening animals, the British grazier stands alone. Beginning, in the early days of the work of the grazier, with animals of the poorest kind, by a close study of their physical characteristics, and of the natural laws which regulate what is called "breeding," he has succeeded in raising classes of stock which in their capacity to increase in bulk, and fatten in the minimum of time with the minimum of food, are excelled by no breeds of cattle in the world. Their excellence is such that they are eagerly sought for by the breeders and rearers of cattle all over the world. And such is the reputation they have universally obtained, that prices are given gladly which some of our readers who come new to the subject will deem fabulous. Of all our breeds, that known as the "Shorthorn" takes the highest rank, and animals of the purest blood have been sent to all parts of the world to improve the indigenous breeds of various countries. With this end in view, and with a just estimate of their value, it is no uncommon thing to read that such and such a breeder in some foreign land, or in our own colonies, as Canada or Australia, has given for a single animal one thousand, two thousand, and even so high a sum as three thousand five hundred guineas—in truth, in a few cases sums much higher than this. This statement alone will give to the noviciate in grazing as a technical calling some conception of the important work done in the way of improving the breed of our native cattle by British farmers.

The High Position of British Cattle Breeding one of the Reasons stated why Farmers should devote themselves to Grazing.

It is in view, indeed, of what they have done, and of the peculiar and highly valuable characteristics which our land and climate possess for the purposes of the trade, that the most practical and the most advanced in science of our agricultural authorities strongly urge upon British farmers the importance of making the breeding and rearing of "stock"—or cattle—the chief work of British farming. They maintain that, taking into consideration the uncertain character of our climate, the fact that our highest normal temperature is much below what is required for the wheat crop to be grown in perfection for the purposes of "The Corn Miller" (which see), in the production of flour for bread-making; and in view, moreover, of the perhaps most potent influence—that of the competition of other and more favoured countries—corn growing, or what is known chiefly as "arable culture," is not, and will never be, a trade which will give the highest return for the lowest outlay; and that what the British farmer has only to look to for his living in the future is the breeding and rearing of stock. In this position those advanced authorities above alluded to maintain lies our chief power in making farming or grazing, in other words cultivated land, pay. And they point out two directions in which this will be brought about. First, that as more breeders of improved stock for the supply of other countries, there is a large and a paying trade to be done, which will last for a long course of years. The second direction is, however, the more important —namely, the ever-increasing demand for flesh meat by our own people, and for which they pay, and have for years, indeed, paid, prices which should be remunerative to the grazier and breeder and fattener of stock. In our remarks in a preceding paragraph we have referred to the great question which has thus arisen of late years for discussion—namely, that connected with the conversion of corn-growing lands into grass lands upon which a larger number of cattle can in the future be reared than has been the practice of the past. There are those, however, who, in considering this important question, overlook certain facts of grave import which will in many localities decide the question as against this proposal of an almost universal change of corn-growing into grass-growing land, or, as it has been very generally put by the public press, the doing away with arable for what they call grass-land culture. And one practical deduction has been singularly overlooked by many: and this is, that even should corn-growing be so widely given over by our farmers as to constitute it a thing of the past, it does not follow that the work of the *arable* farmer will be no longer required.

Some Practical Considerations affecting the Question of Grass- as against Corn-growing Lands—Popular Misconception as to the True Meaning of the term "Arable Land"—An Increase of Arable Culture in reality a Necessity of an Increase in Cattle Breeding and Fattening conducted on the Most Advanced Principles of Agricultural Science.

In other words, arable culture is not confined to the growing of corn, which some seem to think it is, for they talk as though if corn-growing were given up there would be no need for the plough in our cultivation (see the paper entitled "The Agricultural Implement Maker"), but that—and that as a consequence—all land would be under grass. We have elsewhere, in a chapter in the paper entitled "The Farmer," stated certain facts which show how utterly erroneous this view of the matter is. There are many circumstances which greatly affect this so-much-talked-of change. It is very easy for outsiders who are really not acquainted with the facts of the case to advise farmers to devote themselves to stock farming—to become, in fact, what is known as graziers, and to go in for fatting cattle as a trade. But what if there be no stock to fatten? This paradoxical, yet often common-sense way of putting the point, does not seem to have struck many as a thoroughly practical one. But it is so nevertheless. For while the conversion of corn-growing into grass land has been steadily increasing of late, it is a somewhat suggestive, and in many respects by no means a reassuring fact, that there has been little increase in the number of our fattening stock, while in sheep there has of late been a positive and a large decrease. This, then, points beyond all doubt to the important practical conclusion that our graziers must breed and rear more extensively, in order to bring on stock for fattening for the butcher. But this must of necessity be a work of time, which will of itself render the realisation of the hopes or wishes of those who go in for grazing as the work of the farmer of the future very tardy. Another point affecting this is also often overlooked—namely, the fact that the conversion of corn-growing into grass land is not only a costly, but it is a slow process—in many cases a very slow one. On this point the reader will find ample notes in the chapter on "The Farmer" above referred to. Further, as affecting this so-often-talked-of system of doing away with arable culture, let it be understood—what by many is not known, or if known, for one reason or another kept out of sight—that though there is much land existing unfitted for the purposes of pasture or meadow, there are crops to be raised other than that of corn. And, in fact, these crops are required for the purposes of cattle-rearing and fattening, the very trade which, in its proposed extended condition, is to do away—so say many—with all arable culture. We are of those who believe, on the contrary, that so far as arable culture is concerned, a truer, because more scientific conception of what cattle-feeding really is, will bring about a still wider and more extended system of arable culture—or *feeding crop culture*, to give it its more specific and more easily and popularly understood definition. We have yet to learn that it is not merely to grass lands yielding pasture or producing hay, as the sources of cattle food, that the British cattle-breeder has chiefly to look. On the contrary, the time will come—is, indeed, rapidly advancing —when a more scientific system of feeding will be adopted, and which in place of lessening will greatly increase the number of the crops to be raised by the arable farmer. So far, then, from an increase in cattle breeding and rearing—in which, according to many, the future of British farming is to lie—doing away with the work of the plough and the cultivator, it will vastly increase it, and make cultivating (that is, arable) implements and machines even more useful in the future than they have been in the past of British farming. How this is likely to come about, we shall see as we proceed to consider the practical points connected with the production of meat produce —that is, the breeding, rearing, and feeding of fattening cattle. These we propose to consider under three general heads—first, the "Principles of Breeding," second, the "Foods used in Feeding," and third, the "General Management of Breeding and Fattening Stock." First, then, as to the principles of breeding.

Principles of Breeding—Fattening Cattle or Stock.

Although the principles of breeding are the same in the different classes of stock, the object directly in view differs according to circumstances. Thus, in the case of oxen or fattening stock, which are designed when matured for the butcher to be slaughtered for food, the object in view is different from that held in the case of dairy cows. In the case of fattening stock it is the aim of the breeder to have animals which will fatten in the quickest time on the least amount of food. Where dairy cows are concerned, the primary object of the breeder is to give to the animals all those physiological peculiarities which are known from experience to yield large supplies of milk, and this of the richest character, from a consumption of the minimum supply of food. The secondary object is to have such a capacity in the animal that it shall keep in good condition during the period the cow is giving milk, or fatten quickly when it is no longer used for dairy purposes, but "dried off" and set aside to be prepared for the butcher. In the case of sheep and pigs the primary object in both—indeed, the only object in the case of the latter—is to breed an animal which will give the quickest return of meat or flesh for the smallest amount of food; a secondary object in the case of the sheep being points connected with the quantity and quality of the wool. But in all those special cases, the general principle upon which effective breeding depends is the same, and this we shall explain chiefly in connection with the breeding of fattening cattle.

The Production of Butcher Meat.—Conversion of Vegetable into Animal Tissue or Flesh.

What is called "butcher meat" may be considered popularly—although in one sense it is also strictly scientifically true—as the "essence" or the feeding constituents of the vegetable substances upon which the oxen or fattening cattle live. The result of the process of feeding of the animals is the conversion of vegetable into the animal tissues which we call "flesh" or butcher meat. The food of man himself is to a large extent made up of vegetable substances—bread, for example, the great staple of his food substances—but the majority of those which are more strictly and popularly known as "vegetables" differ considerably in character from the vegetables which form the food upon which farm live stock are fed. Thus grass, as afforded by the pasture field, or in the artificially dried form of meadow grass known as hay, may be said to be the staple food of cattle. This grass, although in the advanced practice of modern stock management supplemented by a variety of substances, such as turnips, oil cake, and various seed products—*e.g.*, beans and pease, and Indian corn meal, etc., etc.—may be therefore taken as the typical or natural food of our fattening cattle. All those are purely vegetable, and all are partaken of by the cattle in a crude or the natural form as a rule, although in modern cattle-feeding cooking forms a part of some of the systems introduced. Apart altogether, therefore, from considerations connected with the question of whether a vegetable, or a meat or flesh diet—or a combination of both—is best for man, we know that he has a liking, which may be said to be universal, for animal or flesh food. In the strict sense of the term, then, an ox or a fattening dairy cow may be said to be simply a vehicle by which certain processes can be carried on for converting vegetable substances—some of which man, in his civilized condition does not or cannot eat—into an animal substance which, known as butcher meat or flesh, he can eat, and eats with relish, in one or other of its cooked forms. Hence the ox has been said to be a machine for manufacturing flesh meat out of vegetable substances; and as those are, as we have seen, what man could not himself use, the fattening of oxen may be said to be a means of utilising substances which, so far as he is concerned, would be but waste or useless.

Object of the Cattle Breeder.—The Quickest Conversion by the Animal of the Smallest Weight of Vegetable Food into the Largest Weight of Flesh.

Looking, then, upon an ox as a vehicle by means of which we pass crude forms of vegetable substances through a process or rather processes which change them into the tissues of animal flesh, the object of the breeder is to get an animal which will for a given weight in bulk of vegetable food yield the largest weight of flesh tissue; and this possessing the rich, juicy and tender qualities which—together with a fine colour and flavour—make up the characteristics of the high quality of "meat" which man, in his modern civilized condition, demands. Now, observation, carried on closely and for a long course of years, has shown that while some animals give the largest amount of flesh for the smallest consumption of food substances, and give also this flesh with the qualities so much desired in butcher meat, there are certain peculiar characteristics in the physical structure of the animal which are more or less, and in some cases almost wholly, absent in other animals.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

Embracing the Various Departments of Technical and Industrial Work, such as Mechanics and Machine Design and Construction — Building Design and Construction—General Manufactures, as Textile and Metal—Applied or Manufacturing Chemistry — Industrial Decoration—Sanitary Engineering—Gardening and Rural Matters—Miscellaneous.

6. The Materials of which Machine Belts are made.

Up to within a recent period the material exclusively used was leather; and it is still considered by the great majority of mechanics the best to use, although it has many rivals now to compete with it. Of those new materials, perhaps that which has met with the greatest success is that of vulcanized indiarubber. But a much wider variety of materials have been tried, and with varying success, than the two here named. Flax, wool and cotton have been employed, and belts of the latter substance are now used in the largest mills, and of a great width. Paper has even been introduced as a material for belting; the best linen rags being employed in the preparation of the pulp. Belting, moreover, has not been confined to the use of one material in its manufacture: compound belts have been made with different and apparently incongruous materials, such as leather, and steel or iron. Iron itself has even been used, and with apparent success. Compound belts of textile substances, such as cotton, flax and wool, with indiarubber, gutta-percha and gums have been also made, and some of those combinations have given good results. What is called "Union" belting is a combination of leather and cotton, the cotton being connected between and to the surfaces of two correspondingly broad strips of leather. In the case of leather belts, the hide or skin is invariably tanned—in the best samples oak-bark tanned—the hides being of the very best quality. But raw hides or untanned—that is, simply air- or sun-dried hides or skins—have also been employed in belting, and with decided success when skilfully used. In the earlier periods of machine employment, belts were as a rule very narrow, varying from narrow strips—to which the name of "straps" was more or less correctly applied—of an inch or less in width, up to four, five, or six inches, the last-named width being about the maximum. But as machines were applied to a wider range of work, which required greater and greater power to drive them, the width of belting increased in like proportion. And now that power from prime movers is taken off directly by belts, to the exclusion of the older system of toothed-wheel gearing, we have belts of a width up even to five or six feet and over—breadths which mechanics of the last generation or two would not have believed it possible to be made, if indeed they would have deemed them at all likely ever to be required. This has introduced many new features in the practical art of belt designing and making. Many of those have been the subjects of patents; and the inexperienced reader would be surprised if he were made acquainted with the wide variety of methods introduced, and the large industry, employing many hands and requiring much capital, which the machine belting manufacture has given rise to. Occasion may be had hereafter, in this series or otherwise in the text, to notice some of the most successful systems of producing belts of great width and of corresponding thickness, which may be designated as "built belts," demanded by the requirements of modern belt gearing. In a succeeding "Note" we shall give some results of experiments made to define the relative driving values of belts of various materials as compared with the best made leather belts.

7. The New Standard Wire and Metal Gauge—The "Birmingham" and the "Lancashire" Wire Gauges — Various Technical and Constructive Points connected with the Subject of Practical Interest to the Engineer and Machinist.

It may not be known to all our readers that on the first day of March last a new wire gauge came in force, to be after that date a Board of Trade or legal "standard" under the Act. The employment of this is so far compulsory that contracts or bargains only which refer to and use the new gauge can be enforced legally—that is, law-suits compelling to the enforcement of bargains or contracts can only be maintained when the new gauge is used by the parties contracting. That the old gauges will be used largely, just as weights and measures in great variety are used in markets throughout the country, notwithstanding that we have legal or Act of Parliament "Imperial" standard weights and measures, there is no doubt. The Board of Trade, indeed, foreseeing this, ask for the co-operation of the local authorities throughout the kingdom to give it every publicity in their respective districts, so that by "the common adoption in manufacture and trade of a uniform gauge, the annoyance and loss occasioned by the present variety of sizes in use, of which complaint has been made, may no longer arise." This getting rid of a number of so-called "standards" or gauges, and having but one, and that issued by the highest legal authority, an Act of Parliament, to which all could refer and which all could use, is the object aimed at by this new standard. But although the Board of Trade Standard Gauge for Wire and Metals has been arranged by high scientific authority, after consultation with the "various institutions, local authorities, manufacturers and others practically interested in the use of wire gauges," it would seem by some to be doubted whether after all a standard based on a truly scientific or accurate principle has been attained by this new one. Many, indeed, join issue with those who support it, and believe that, in the words of one authority qualified to give an opinion on the subject, the Board of Trade have "added to" rather than "diminished" the irregularities attending the whole system of metal gauges. How far this allegation is true remains to be seen; meanwhile we have to deal with the fact that there is now a standard wire and metal gauge to which all can refer as one having the legal status which an Act of Parliament—permissive in one sense though it be—confers. As to having a standard which would be followed by all, no argument is required to show the great advantages of it; the practical difficulty is, however, to get universal assent to it. So long as the matter is left open, so long will it be found in practice that while some will gladly accept, others will refuse it. While so marked is the influence of prejudice or long continued usage in all matters of trade or manufactures, that it may be looked upon as a settled matter that a large number of those using metals will continue to use the old or ordinary gauge, of which that known as the "Birmingham Wire Gauge" is the one which has hitherto been almost the only one in use—that known as the "Lancashire" being, as its name might indicate, chiefly used in that county, although even there the Birmingham has exercised the widest sway. We have prepared a table showing the relative measurements of the three gauges—the Board of Trade Standard, the Birmingham, and the Lancashire. It will be observed that what may be called the "legal standard," the first of those, retains the nomenclature, or rather the "numbers," used in the Birmingham Wire Gauge. Those have been so long established, and have taken such hold of the mechanical mind—or rather, as we should say, the minds of mechanics—that it would have been useless to have attempted to substitute new names or "numbers" for the different sizes. The subject of metal gauges is one which embraces so many features of technical and practical interest, and has engaged the attention of so many scientific men, that we shall be well repaid by directing attention to them. Although we made the present series of notes much more extensive than the scope of this department of our work permits, we could not embrace even a brief notice of all which has been made known in connection with it. We hope, however, to draw together from a wide variety of sources a few notes which will be interesting as well as of practical service to our readers, and which under this section will be given from time to time.

TABLE OF THE LEGAL OR "NEW STANDARD," "BIRMINGHAM" AND "LANCASHIRE" WIRE AND METAL GAUGES.

"Nos," the same as those of the Birmingham or old Gauge.	Equivalent Decimal Parts of an Inch in the Three Standards		
	New or Legal Standard.	Birmingham Wire Gauge.	Lancashire Wire Gauge.
No.			
0000000 7/0 or 7°	0·5000		
000000 6/0 or 6°	0·464		
00000 5/0 or 5°	0·432		
0000 4/0 or 4°	0·400	·454	
000 3/0 or 3°	0·372	·425	
00 2/0 or 2°	0·348	·380	
0	0·324	·340	
1. . . .	0·300	·300	·227
2. . . .	0·276	·284	·219
3. . . .	0·252	·259	·209
4. . . .	0·232	·238	·204
5. . . .	0·212	·220	·201
6. . . .	0·192	·203	·198
7. . . .	0·176	·180	·195
8. . . .	0·160	·165	·192
9. . . .	0·144	·148	·191
10. . . .	0·128	·134	·190
11. . . .	·116	·120	·189
12. . . .	·104	·109	·185
13. . . .	0·092	·095	·180
14. . . .	0·080	·083	·177
15. . . .	·072	·072	·175
16. . . .	·064	·065	·174
17. . . .	·056	·058	·169
18. . . .	·048	·049	·167
19. . . .	·040	·042	·164
20. . . .	·036	·035	·160
21. . . .	·032	·028	·157
22. . . .	·028	·025	·152
23. . . .	·024	·022	·150
24. . . .	·022	·020	·148
25. . . .	·020	·018	·146
26. . . .	·018	·016	·143
27. . . .	·0164	·014	·141
28. . . .	·0148	·013	·138
29. . . .	·0136	·012	·134
30. . . .	·0124	·010	·125
31. . . .	·0116	·009	
32. . . .	·0138	·008	
33. . . .	·0100	·007	
34. . . .	·0092	·005	
35. . . .	·0084	·004	
36. . . .	·0076		
37. . . .	·0068		
38. . . .	·0060		
39. . . .	·0052		
40. . . .	·0048		
41. . . .	·0044		
42. . . .	·0040		
43. . . .	·0036		
44. . . .	·0032		
45. . . .	·0028		
46. . . .	·0024		
47. . . .	·0020		
48. . . .	·0016		
49. . . .	·0012		
50. . . .	·0010		

8. Bessemer Steel Castings.

So very remarkable has been the success of the Bessemer process of steel making—such a complete revolution has it brought about in certain methods of working in the "iron trade"—to use here the generic term—and so brilliant has been its commercial success, creating fortunes, and making men "rich beyond the dreams of avarice"; and so frequently have its triumphs been recorded in the pages of the public journals, that there must be very few even indirectly connected with technical trades and industry who have not some acquaintance with the general features of this remarkable process. For those who desire to know fully the principle upon which it is based, and the details of its practice, we name the paper given in the text, "The Steel Maker," as one which will afford full information on these points.

Complete as has been the revolution in certain outlets for the use of steel which the Bessemer process has effected, and enormous as are the bulks of this new metal which have been made by it, some of our readers will no doubt be surprised to learn that notwithstanding this its uses are very limited. So limited that it may almost be said that it is only in one department of construction that it is used. This is in the making of steel "rails" as substitutes for the wrought iron or malleable iron rails so long used exclusively, and still largely used, by railway engineers. No doubt it is used, and even in one sense very largely, for other departments of construction, as in ship building, beam and girder work, bridge work, etc., etc. But large relatively as is the weight of Bessemer steel made for those purposes, so small is this as compared with the weight otherwise used for rails, that practically many have come to look upon "Bessemer steel" and "rail steel" as synonymous terms. So much is this the case that, to quote the words of an authority, "there does sometimes appear to be a danger of this splendid material being neglected for other purposes, and its use for rails becoming its ultimate destiny."

As our readers who have a knowledge of the iron trade know, cast iron was at one period exclusively used for all kinds of constructive work—framing of all kinds, beams and bridge work in all its varieties being made only of it. In process of time, as the manufacture improved and the attention of engineers was directed to it, wrought or malleable iron displaying such marked advantages over the older material, was gradually substituted for it, till at last cast iron as a constructive material, in works of the above-named classes, had practically wholly disappeared. And now a similar process of the displacement of one material by another is going on—has for some considerable time been going on—in which Bessemer steel is taking the place of wrought iron. Some engineers, indeed, do not admit that the metal made by the new process is a steel at all, but only a very superior form of wrought iron. Even generally it is designated as "mild steel," as distinguishing it from the older, and what may be called the established forms of steel, known as crucible or "cast steel," to which many insist that the name "steel" has—along with the other form known as "blistered"—alone the right to be given. With this merely passing allusion to a controversy which has long been carried on by practical metallurgists, we proceed to remark that this substitution of Bessemer or mild steel for wrought iron in the numerous classes of construction for which the latter was exclusively employed for a long period, together with its use for rail making, would seem to be the limit which is generally placed upon the employment of the new metal.

In those limited directions the characteristic manufacturing feature of the mild steel is that it is rolled or forged in the same manner as wrought iron. This offers a marked contrast to the manufacturing characteristic of crucible steel, which admits of an endless variety of form being given to articles made to it, which could not be given to mild steel by treating it in the same manner as wrought iron. Many of our readers will be aware of the remarkable class or classes of work done of late in the casting of bodies used in a wide variety of constructive work in crucible steel, Siemens' "open-hearth" (see "The Steel Maker" in text for a description of this), Krupp, and other kinds of steel. But although work to some extent has been done in the way of forming bodies of Bessemer steel by the process of "casting," and although the work done has been eminently satisfactory, still it cannot be said that it is a generally accepted truth, that all the advantages obtained by the system of casting—which gave, and still gives, the value to cast or ordinary pig iron—can be obtained in the case of the Bessemer steel. There are some, however, who do believe, as the result of their practical experience with Bessemer mild steel castings, that just as cast iron for a wide variety of constructive work was displaced by wrought iron—and as this latter material is largely displaced now, and is likely still more completely to be so, by Bessemer mild steel manufactured by the process the same in principle as that used for wrought iron, so will cast iron as a material for moulding, with all its advantages as such, be displaced by Bessemer mild steel cast or moulded, not wrought or rolled.

All new methods or systems are met with a variety of objections, and difficulties not a few are either experienced or are stated to exist detracting from the utility of the new methods. This use of Bessemer mild steel as a casting material is no exception to this general rule. Brought to the front only recently, it has already clustered round it a number of opinions and conjectures which give a high degree of practical interest to the question. The fact that very great advantages would result from a system of forming the various objects used in construction, and now made of wrought iron, by the process of casting, as carried out in the case of pig or cast iron, no one disputes. The point disputed is that objects so cast are either positively or likely to be unsound, and therefore not to be trusted in construction where absolute soundness is essential. And this difficulty is based on the fact, which is also disputed by no one, that Bessemer mild steel as ordinarily manufactured is so far from being a homogeneous metal—that is, of equal character throughout its mass—that the opposite character, or that of a "honeycombed" body, is the feature of the metal. On all sides the existence of "blow-holes" in Bessemer mild steel is recognized as its characteristic, and is of course deplored by all. That this great evil can be got rid of is asserted by some, and by others it is maintained that by careful manufacture it can be altogether prevented. On those two points much information of a very interesting because thoroughly practical character, affecting closely the future of Bessemer mild steel as a constructive material, applicable to a wider variety of purposes than it has hitherto been applied to, has recently been made public. To a brief *resumé* of this we intend to devote a few notes in succeeding Supplementary Sections of the TECHNICAL JOURNAL.

9. Utilization of Waste Soap.

In the woollen industries a large amount of soap is used for washing and milling. The goods are repeatedly run through a strong solution of soap, and pressed between rollers after each emersion. After a time the soapsuds become dirty and unfit for further use, and are run off as waste. During the process the soap removes the grease and other dirt adhering to the fibre; but the fat—*i.e.* the most valuable part of the soap—is in no way altered, and if collected and properly washed would be fit for manufacturing into soap once more. The recovery of this fat is a problem of no small financial importance to firms which use hundreds of pounds' worth of soap every month. The following method is adopted in many places in this country and the Continent. The waste wash-water is run into large tanks, and either vitriol (sulphuric acid), or in place of this spirit of salt or muriatic acid (hydrochloric acid) is added, with stirring, until the liquid turns blue litmus distinctly red. The acid combines with the alkali of the soap and precipitates the fat, which being lighter than water, on standing several hours, completely rises to the surface, bringing with it other impurities, short fibres, etc., and the heavy mechanical impurities, sand, etc., sink to the bottom. The aqueous layer is run off, and the impure semi-fluid fat remaining in the tank is pumped into press filters, and the water yet retained in admixture with it is pressed out. The residuum is now transferred into canvas sacks and placed in hot presses, an oily liquid of fatty acids is pressed out, the impurities remaining in the sacks. The fatty acids thus obtained are run into the soap chaldrons for conversion into soap. This is effected by the simple addition of carbonate of soda, with heat and agitation, until neutral. The mass is kept boiling during the union of the alkali and fatty acid, in order to facilitate combination and to effect the escape of the carbonic acid which is evolved. A good soap of a brown colour is obtained, fitted again for use by the wool-scourer. A pure white soap may be obtained from the fatty acids if they are first distilled with steam, which yields pure white fatty acids. The residuum left in the sacks in the filter process may be used as manure, as it contains a considerable proportion of nitrogen (see the Prize Scheme of the TECHNICAL JOURNAL for a prize offered in connection with the general subject of the Utilization of Waste Products).

10. Data useful in Mechanical Calculations and making out Estimates for Work.

The weight in pounds of different metals used in construction per "square foot" of varying thicknesses, stated in sixteenths of an inch, beginning with 1 and rising by 2. *Cast Iron:* $\frac{1}{16} = 2·34$ lb., $\frac{3}{16} = 7·03$, $\frac{5}{16} = 11·71$, $\frac{7}{16} = 16·40$, $\frac{9}{16} = 21·09$, $\frac{11}{16} = 25·78$, $\frac{13}{16} = 30·46$, $\frac{15}{16} = 35·15$ lb. The thicknesses intermediate, giving the eighths of an inch, may be found by multiplying the weight of the 16th by 2: thus the seven-eighths will be fourteen times this. The weights due to the thicknesses stated in the order above of the other metals are as follows, beginning with *Wrought Iron:* 2·52, 7·57, 12·03, 16·40, 21·09, 25·73, 30·46, 35·15. *Steel:* 2·55, 7·65, 12·76, 17·86, 22·96, 28·07, 33·17, 38·28. *Brass:* 2·73, 8·20, 13·67, 19·14, 24·69, 30·07, 35·54, 41·01. *Copper:* 2·89, 8·67, 14·45, 20·23, 26·01, 31·79, 37·57, 43·35.

11. Rule to ascertain the Weight per Square Foot of Cast Iron Plates of given Thicknesses.

Take the thickness in inches or in decimal parts of an inch, and multiply 144 by it, divide the product by the constant 3·84: the result is the weight required. To facilitate calculations of this kind, as well as those connected with the cubical contents of metal and other bodies, the decimal equivalents of fractions of feet and inches are exceedingly useful. For those, and method of using them, see a Note in next number of the TECHNICAL JOURNAL, entitled—No. 14, "Calculating surfaces and contents of pieces of metal or wood when fractions are given in the dimensions."

12. On Boro-Glyceride as a Food Preserver.

This newly discovered, or hitherto unnoticed, compound has been applied by Professor Barff to the preservation of food-materials. It is formed when 92 grammes of glycerine are heated with 62 grammes of boracic acid, water being at the same time formed. Chemically, it is represented by the formula $C_3H_5BO_3$. When pure and free from water, it is a hard, brittle substance, resembling ice in appearance. It dissolves readily in warm water, forming a strongly antiseptic liquid, which has little or no taste, and is probably perfectly innocuous to the human system, although recent authorities on the subject have not yet come to a unanimous decision on this all-important point, considered in relation to the preservation of food for human beings. Animal and vegetable substances when treated with this compound will keep perfectly fresh and uninjured for a long time—in some cases for months—which without the application of the substance would "go bad" or putrefy in a few days. Boracic acid has long been known as an antiseptic, and has for many years been applied to the preservation of foods, but only in a very limited number of cases, such as milk, etc., though its combination with glycerine renders it suitable for almost every kind of food and drink. Animal food, beef, fowl, fish, etc., are either steeped in a solution of the compound, or the solution is injected into the arteries.

13. Manufacture of White Lead.

White lead is one of the most important pigments used in painting: it forms not only the best of white pigments, but the "body" of nearly all others. It is a pigment of pure white colour, possessing great density and opacity—which latter qualities constitute the important character of "covering" power, or the capability of being spread over a large surface when used as a paint alone or in conjunction with other colouring substances. It is composed of carbonate of lead, together with a little hydrate of the same metal. Like other lead salts, it is very poisonous, and this is the great objection to its extensive use as a paint; but notwithstanding many attempts—not wholly unsuccessful—it has never yet been superseded for many purposes by other white pigments. It has a "body" or solidity and pure whiteness not possessed in the same degree by as cheap a material. The bulk of the white lead manufactured in this country, America and the Continent is produced by the old fermentation method, depending upon the principle that common lead, when exposed to the air and moisture, slowly becomes coated with a white layer consisting of carbonate and hydrate of lead. This is chiefly due to the presence of carbonic acid in the air. It is greatly facilitated by the presence of acetic acid vapours. The commercial process for the manufacture is an application of these facts. A series of brick chambers called "stacks" are built, generally having an area of about 25 by 14 feet. Each chamber is provided with an opening in front for filling the stack; and a similar one at the back-end for emptying when the time arrives. The floor of the stack is covered with a layer of porous ashes. On the top of this is laid a bed of spent tan, partially putrefied or decomposed by previous exposure in heaps to the action of air and moisture. On this layer of tan are laid blocks of birch wood about 16″ diameter, to support rows of earthen pots which are placed between the blocks, resting on the tan. The pots are placed close together, over the entire layer, except a space of about 6″ along the sides. The pots are filled with dilute acetic acid, or weak vinegar, containing ½ to ¾ of 1 per cent. of pure acetic acid, $C_2H_2O_2$. On the top sides or edges of these pots, supported on boards of wood, are placed sheets of lead, to the depth of about 5 or 6 inches; 6 or 8 inches above this is constructed a wooden shelf, upon which is laid another layer of tan and rows of pots containing dilute vinegar exactly like the bottom one, except that the layers of tan may be of diminishing depth as they approach the top. Ten to fifteen such layers are made, and the topmost layer is covered with a layer of bark, a few feet from the roof of the building. The space of about six inches around the walls is generally filled with clean straw. The whole being now completed, the stack holes are closed, the building being entirely closed in, and fermentation of the tan allowed to go on, by which a large amount of carbonic acid is generated, and the temperature is considerably raised, reaching from 120° to 140° Fahr., which hastens the conversion of the lead into white lead by evaporating the acetic acid from the weak vinegar contained in the pots. Sometimes the walls are provided with one or two ventilators, which may be entirely closed when desired, for the escape of steam and condensed water, which is given off during the fermentation. It is important, in the making of white lead according to this method, to guard against discoloration by the condensed water charged with brown matters derived from the tan falling into the white, and for this reason in large stacks it is necessary to have ample ventilation for escape of steam.

After several weeks' action, the sheets of metallic lead are found to have greatly increased in weight and bulk, and to be converted into white masses of carbonate and hydrate of lead, but still retaining the shape of sheets. These are removed, layer after layer, into tanks of water, where the corrosion or coating of white lead is scraped off and collected in tanks of fresh water, thoroughly washed, allowed to settle, the water drawn off and the white powder collected, ground in mills to fine powder, dried, and is ready for the market. In the centre of the layers of lead cakes of lead yet unacted upon are found. These are used up in the next charge of the stack.

The amount of lead which is actually converted completely into white does not exceed 60 to 70 per cent. of the lead employed, and the increase in weight consequent on the conversion into carbonate of lead amounts to about 20 per cent. A stack covering an area of 20 feet by 12 feet, and holding 13 layers of lead, is said to require from 40 to 45 tons of lead; each layer takes about a thousand pots, 5½ inches in diameter, holding 200 gallons dilute vinegar. The lead employed in making white lead must be free from impurities, especially copper and antimony, as the presence of these metals impairs the whiteness of the white lead obtained.

Several other methods than the above are in use at the present time for the manufacture of this useful pigment, but that just described is the more extensively employed one. The only other method that demands notice here is the Milner process, which is now successfully carried on in this country, and will probably ultimately entirely supersede the fermentation process; depending as it does on a more exact action, occupying two days instead of several weeks, as in the old process, and requiring but very simple plant. The process depends upon the formation of an oxychloride of lead, which takes place when certain proportions of litharge (*i.e.*, protoxide of lead), common salt and water are ground together. The mass is gradually converted into a soft white pulp, with elevation of temperature and formation of an alkali. In practice a mixture in the proportion of 4 lb. dry flake litharge, previously carefully ground and levigated, 1 lb. common salt dissolved in 16 lb. of water, is placed in a wooden pug-mill, made of pine or elm, but not of oak. The mixture is continuously agitated in this mill for three hours; the mass gradually thickens till the consistence of thick paste is attained; it then begins to become thinner, indicating completion of the action. By this means there is obtained an insoluble basic chloride of lead, suspended in a solution of sodium chloride (or common salt) and caustic soda. This is run into an iron cylinder lined with sheet lead, 16 ft. in height and 8 ft. in diameter, provided with wooden agitators or paddles, moving on a horizontal axis, arranged so that the arms move alternately above and below the surface of the liquid. The agitators are now set in motion, and a stream of carbonic acid gas introduced into the pasty mass from a pipe passing through the bottom side, and continued until the liquid ceases to be of alkaline reaction; the stream of gas is then continued a little longer, and then stopped. The point at which to arrest the stream of carbonic acid is one of great importance, as if continued too long a product is obtained containing too much carbonic acid and deficient in covering power. The right point being reached, the current of gas is stopped and the mass is run into tanks of water and allowed to settle; the water is run off and the white powder is collected on filters, ground, dried, and is ready for market. The carbonic acid gas used in the process may be generated from chalk and coke heated in a kiln and washed by passage through water. The product obtained is equal in quality to that obtainable by the fermentation method, and possesses in fact the same chemical composition.

14. Value of Rain Water for Domestic Purposes—Calculations connected with the Sources of Supply, as Roof Surfaces, etc.—Storage Cisterns and Tanks.

That the collecting and storing up, or as the generally used phrase is, the "saving" of water arising directly from the rainfall could be carried out at comparatively little cost, and with very marked beneficial results in more ways than one, is obvious enough, on even a brief consideration of all the facts of the case. That the amount of water which can be collected directly from the rainfall exceeds the wants of rural populations, including the supplies required by the farm buildings of every district, is established beyond a doubt. And one feature too often lost sight of, and which gives a practical value to all schemes of saving, is, that the supply may be looked upon as constant; and this from the fact that, the rainfall being distributed over the whole of the year, the water taken from any collecting place is being constantly replenished—the excess of demand on the store of water at one time being thus met by the excess of supply at another; the average of the year being, as above stated, far in excess of the wants of the population.

And it certainly is a curious and a fortunate coincidence—and which indeed, from long continued observation and extended experience, may be said to be a rule—that the roof surface of a house affords gathering or collecting space for a supply of rain water which if stored up will be, if not in excess of the requirements of the family residing in the house, sufficient to meet their wants. The same remark holds good as regards farm buildings where stock is kept.

It is right to state that certain opinions have been stated, and as we think, unfortunately too dogmatically stated, as to rain water. These tend to convey a conviction to the minds of many not conversant with the details of the subject, that rain water is impure. Not in itself so, for it is impossible to contradict the fact that naturally it is the purest water which can possibly be obtained from any source; but that impurities are derived from the atmosphere through which, and from the surfaces upon which it descends, as those of roofs, etc., no one would deny. Now, as regards the atmosphere, whatever may be said against that which floats above manufacturing towns, nothing with any fair reason can be brought forward against that in the country. Oddly enough, those who have preferred this charge against rain water are the same persons who uphold the country atmosphere as the healthiest. Now, both views cannot be right: if country atmosphere be a source of impurity for rain water, it ought—one would think—by parity of reasoning to be one also so far as health is concerned. And as regards the contaminating influence of the surfaces on which it falls, the only contamination at all probable in the country is that arising from leakage, and the droppings of birds. And this is so trifling in amount as to be scarcely worthy of being reckoned. But on the whole subject experience has been such as to cause what may be called a universal consensus of opinion in favour of rain water for domestic and by consequence for farm live stock purposes. The population of whole districts use nothing but rain water, and for the sufficient reason, if none else existed, that no other can be obtained, at least not without involving great expense. And even in the manufacturing districts, where the atmosphere cannot be said to be pure according to the popular standard of purity, it is well known how largely rain water is used. Even when impurities such as those which have been stated do exist, they can be removed by even the simplest and cheapest methods of filtration.

In all discussions on the water supply question, the amount per head per day stated to be absolutely required is in reality far in excess of that which is so. This amount, twenty-two gallons, is to cover waste arising from leakage and other sources so generally met with in towns, and the worst of all wastes, the wanton waste so prevalent in houses. But when water is carefully used—and when want is found to be the concomitant of waste, careful use is gradually taught—a very much less quantity is required. Three gallons is an ample allowance, taking old and young together; and one has only carefully to consider what he does use or is used—that is, what he absolutely and only requires—for him to discover that less than this quantity will really be ample.

Taking, then, this lesser quantity at two and a-half gallons per day, this will be supplied from 500 square feet of surface, and this superficies will be given by a cottage of the average size, including its outbuildings. As the roof surface is the actual collecting area, this varies with the style and the disposition of the roof; but it is a very small cottage which will have only 500 feet of roof surface. Again, the supply per head depends upon the number of inhabitants, and we incline to think that five is nearer the average than six. If so, and taking, with an average annual rainfall of twenty-two inches, the water stored from 500 square feet of slate roofage at 5700 gallons, the daily average supply will be, say fifteen gallons, which divided by five gives three gallons per head per day. Thatched or straw-covered roofs not being adapted for rain water collecting, for many and obvious reasons, are not to be considered as watershed surfaces for practical use; although even the rain water from them should not be wasted, but stored up, if for no other purpose than for privies and clothes (at least rough clothing) washing, for which it will, even without filtration, be much better than the average quality of water obtained from springs and wells. Mr. Wheeler, C.E., who has had large experience in the water supply of rural districts (his paper before the "Water Congress," so to call it, held by the Society of Arts in its Journal number for August 8th, 1879, will well repay perusal), recommends as the result of his experience that the storage tank should be sufficiently large to contain a supply for 78 days. To ensure this, for every square foot of roof surface the tank should have a capacity of 2½ gallons. Thus, a tank for a cottage with 500 square feet of roofage should be 6 feet deep, and 6′ 6″ in diameter; this will hold 1200 gallons up to the level, below the springing of the arched top. If constructed of brick and mortar, in form a circle in horizontal section, the cost will be somewhere about one penny per gallon. The larger the tank the less its cost per gallon; hence the value of the system of making one large tank to supply several cottages. As a material not only cheaper than brickwork, but in every other respect superior, there is none which can hold its own against Portland cement concrete. A tank of this material can be constructed much more quickly than one of brickwork, even by any common labourer or unskilled workman, and when set it may be looked upon as equal to a tank cut out of a single solid stone. (See Note No. 3 in p. 41 (Part I.) on this material.)

15. Data for Estimating the Feeding Value of Farm Grasses for Live Stock.

(Col. 1, *Flesh Formers*; 2, *Heat* or *Fat Producers*; 3, *Water*; 4, *Woody Fibre*; 5, *Ash*.)

Table showing Food-value of Grasses and Hay.

GRASSES.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Rye grass . . .	3·37	12·08	71·43	10·06	2·15
Italian rye grass .	2·05	14·11	75·61	4·82	2·21
Lucerne . . .	4·40	19·11	73·41	...	3·08
Sainfoin . . .	3·51	17·43	77·32	...	1·73
Vetch . . .	3·56	12·74	82·16	...	1·54
CLOVERS.					
Red clover . .	3·60	13·78	80·64	...	1·97
White do. . . .	4·52	10·26	83·65	...	1·57
Yellow do. . .	4·48	15·94	77·57	...	2·00
Alsike do. . .	4·82	16·44	76·67	...	2·06
HAY.					
Meadow grass hay .	10·69	40·17	16.94	27·16	5·04
Aftermath or second crop of do. . .	10·75	49·74	18·05	19·02	7·46
Clover hay . .	13·52	64·43	16·84	...	5·51

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(3) "Steam raising" for motive-power purposes constitutes one of the most important of the many important departments of mechanical engineering. The work to be done is of a dual character—the combustion of coal and the quick evaporation of water, each process carried on in its special appliance; in the one case the furnace, in the other the boiler. Shortly defined, the raising of steam in boiler practice may be said to be the "boiling of water." Simple as this process is—and what every one assumes to understand—it is one nevertheless surrounded with points of great scientific interest; but, so far from being a simple subject, the very definition of what "boiling of water" is has not yet been arrived at in a way which every one consents to as accurate. And of necessity mixed up with it is the process of "fuel combustion," whether that be solid or gaseous, solid fuel or coal being almost universally, gaseous only exceptionally, used. We here introduce two subjects of the greatest possible practical interest to all classes engaged in industrial processes—for all, or nearly all, demand "steam power" for their work. On both of these subjects we shall have a few paragraphs to give.

(4) In another part of our work the reader will find a paper or two on the use of "Portland cement concrete." This material is now applied to such a wide variety of useful and important purposes that all points connected with its practical use are interesting to a wide circle of industrial workers. Largely as it is used, we have much yet to learn respecting it, its action or behaviour under certain conditions and circumstances; and every now and then something suggestive is cropping up concerning it. It is only recently, for example, that it was discovered that the admixture of "sugar" had a remarkable effect on the qualities of the concrete. In looking about for a useful addition to such a rough, bulky body as concrete is—or "confection," as the French might call it—one would suppose that a condiment, and that sugar, would have been amongst the last of substances thought of as likely to be of use. But the point opens up some suggestions of such great scientific and practical interest that we may have something further to say about it in a future paragraph. Meanwhile it may to the young reader be suggestive of some general considerations as to what strange directions science and practice may take.

(5) In paragraph No. 3 we opened up the subject of steam raising, which we explained as a dual operation or process—the "boiling of water" to secure its "quick evaporation," and this effected by the agency of heat, evolved by the "combustion of fuel" either in the solid or gaseous condition. And we remarked that these operations carried with them points of the greatest importance to a large number of industrial works and processes. Glancing first at the operation of "boiling," whether of simple water in the case of steam raising for motive-power purposes, or of water mixed with various substances, as in brewing, distilling, dyeing, and the like, simple as the operation appears to be, the young reader may be surprised to learn that scientific men have been so far from agreement as to what boiling is, that they have not formulated a definition which is accepted by all as correct. And important as its applications are, and dominating as they do such a wide variety of industrial work, the subject has scarcely received in times past that amount of attention from scientific and practical men which this importance would seem to demand. But this reproach is now being removed, and recent researches have resulted in a new view being taken, which seems destined to completely revolutionise the practice of boiling—modifying, or rather changing, previous conceptions as to what the operation was. (*a*) Evaporation, or the production of vapour from water, is going on at all temperatures, although that vapour is only visible at certain high, or comparatively high, temperatures. Even in winter water will evaporate or dry up from pools on the road. This evaporation increases in rapidity, and the volume of vapour resulting becomes greater as the temperature increases; and when that temperature reaches a certain indicated point the vapour passes off freely, being as it were projected from the water, which becomes more or less violently agitated—a condition to which the name of ebullition is given. This temperature is, under ordinary circumstances, and at or about the sea level, 212° in the Fahrenheit scale of the thermometer, which is therefore called the "boiling point." (*b*) This particular temperature of 212° is that due to the pressure of the atmosphere at sea level, as indicated by a certain height of the mercury in the barometer. But if we reduce that pressure—as by ascending a mountain—we lower the point in the thermometric scale at which water boils, and that in proportion to the lowering of the barometric scale

—that is, the reduction of pressure. (*c*) Conversely, if we increase the pressure of the air, or of its own ejected vapour, on the surface of the heated water, we increase the temperature at which the water boils, and by consequence that also of the vapour, or steam—as water vapour created under pressure is called—which is passed off. And this increase of temperature and increase of what is called the "boiling point" in the thermometric scale is in proportion to the increase of the pressure acting on the water being evaporated: we thus see that the term "boiling point" of water is one purely relative, not absolute, as many seem to think it is. (*d*) Expressed in precise scientific terms, the boiling point of water—or of any liquid—is "the temperature at which a saturated vapour is subjected to a pressure equal to that to which what is called the free surface of the liquid is subjected." In other words, a boiling water is a "supersaturated solution of its own vapour." By supersaturated is meant that condition in which no more vapour can be taken up—just as a salt solution, for example, is said to be supersaturated when the liquid will dissolve or take up no more of the salt. What is meant by the term "free surface," in the definition named above, we shall see when we come to explain how efficient economical boiling and quick evaporation can be facilitated by certain modes of working, the attainment of these two objects here named being what the engineer aims at in the steam engine boiler working, and indeed in every industrial process in which boiling is the main feature. (*e*) We have now arrived at that point at which we have to inquire how this vapour, the result of the operation of boiling water, becomes a source of mechanical force or power, by the use of which work of various kinds is done; in other words, how heat, the product of the combustion of the fuel, is converted into force by boiling water. From this we perceive that, as first demonstrated by Joule, the eminent Manchester scientist, "heat" and "mechanical force or power" are convertible terms: that is, a given amount of heat is the representative, so to say, of a given amount of force, or is the measure of it; so that, if we know what heat we have at disposal, we can calculate how much force or power capable of doing work we have at command. And, conversely, mechanical force is the representative of a certain amount of heat; so that, if we know the force or power we have capable of doing work, we can tell how much heat it took to produce it. (*f*) But before being able to make these conversions or calculations we cannot deal with abstract statements; we must have something definite to work with. This is furnished us in what are called "units," the units of heat and of mechanical work. A "unit of heat" is that amount or quantity of it which will raise one pound weight of water one degree in temperature. A "unit of mechanical force" is the power or weight which will raise one pound weight a vertical height of one foot in the space of one minute. Work done, or mechanical force expended, is thus expressed in what are called "foot-pounds" of energy or force. A "unit of heat" was found by Joule to be equivalent to or convertible into 744 units of mechanical force, hence called "Joule's equivalent"; that is, the force which we may say to be present in the unit of heat, or the heat required to raise a pound of water one degree in temperature, is equal to the raising of 744 lb. one foot high per minute. It will be observed that water is the body selected to represent the unit of heat. This has not been done from obvious conveniences which this body presents for use in various ways, although this consideration was not lost sight of; but because, of all bodies, with the exception of hydrogen gas, water possesses the greatest "capacity for heat," known as the "specific heat." Hence water is selected as the "standard" by which the specific heat of all bodies is measured, or with which it is compared—water being put down as 1000. Now, it is water which is used for steam-raising purposes, and the heat is obtained in this country almost universally by the combustion of coal, water being placed in a closed vessel termed a boiler, which, in relation to the steam engine, is what the lungs are to the human body, supplying it with air for breathing. If, then, by the burning or combustion of fuel—coal generally—we get heat to raise the temperature of the water, and that produces its boiling, and that again vapour, which, as steam is used to work the engine by its inherent force, to which the name of pressure is given, it follows that the operation of boiling is itself the exhibition of force, as the vapour is the ultimate stage of the production of heat by the combustion of the fuel, and the heat represents, or is convertible into, so much mechanical force. We shall see in a succeeding paragraph in this section how this force is created and excited in the act of boiling of water—from which may be deduced another theory of boiling, or what, if taken in conjunction with the theory we have already named under (*d*), will give the reader a clear conception of what boiling is, and how it leads to views and notions which, by quite revolutionising old conceptions and views held for long about it, open up the prospect of great advances being made in our furnaces for the combustion of fuel and in our boilers for the raising of steam. From this the young student in industrial science will perceive that much interesting and practically valuable matter for his consideration lies before him in succeeding paragraphs under this head.

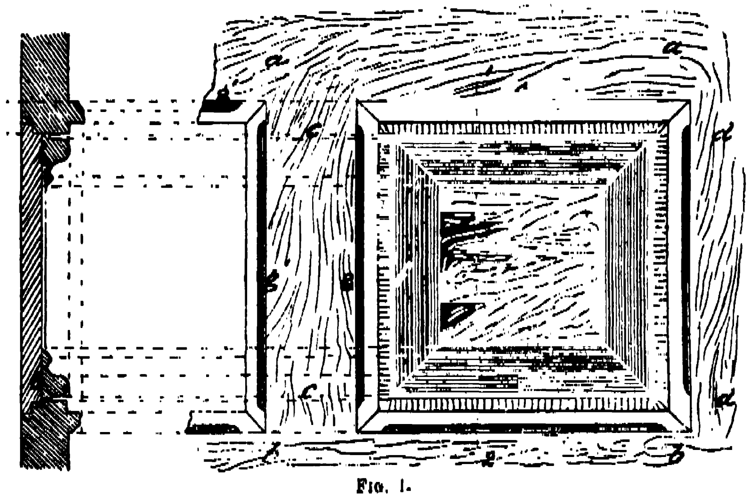
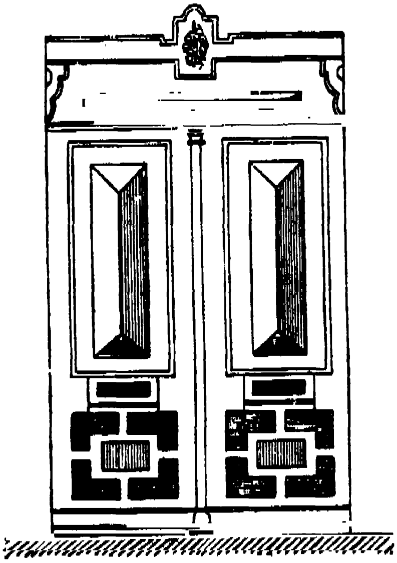


Fig. 1.



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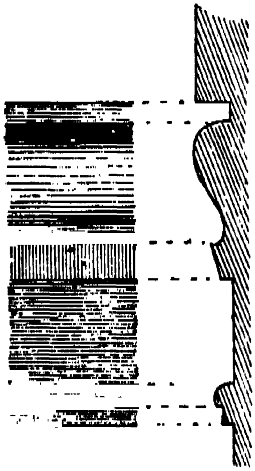
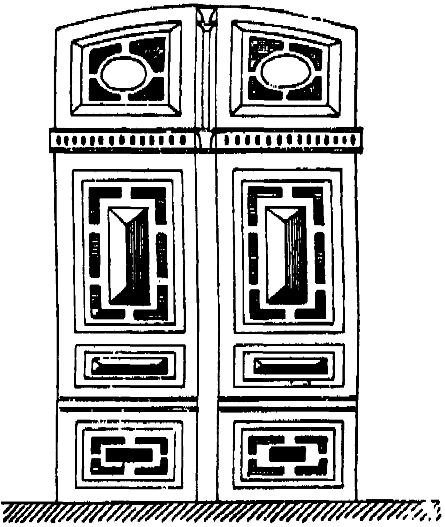


Fig. 3.



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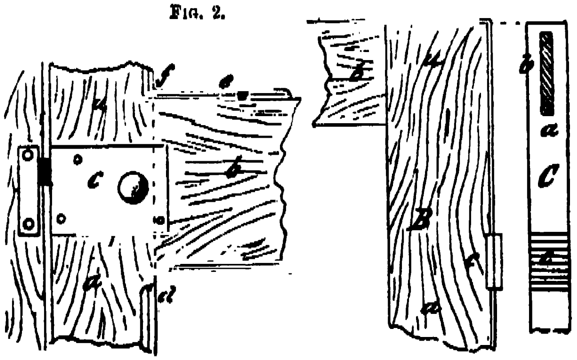


Fig. 5.

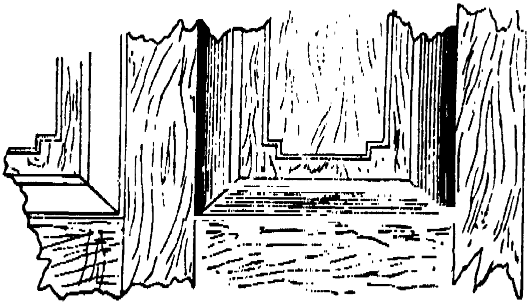


Fig. 6.

Doors, Panels, and Details of Doors.

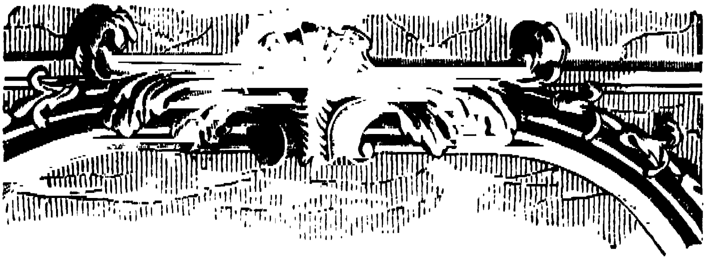


FIG. 1.

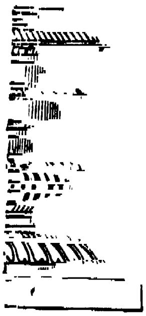
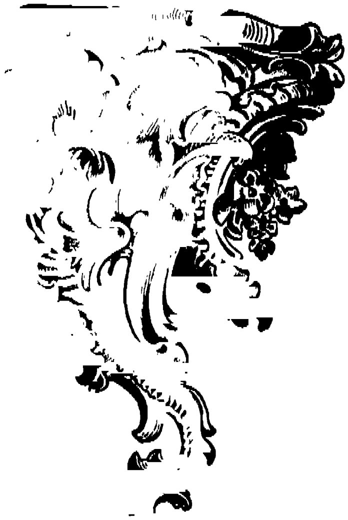


FIG. 2.



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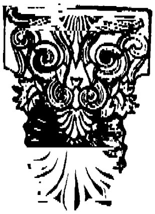


FIG. 4.

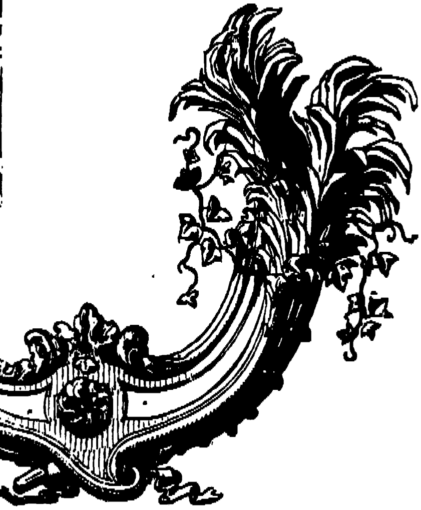


FIG. 5.

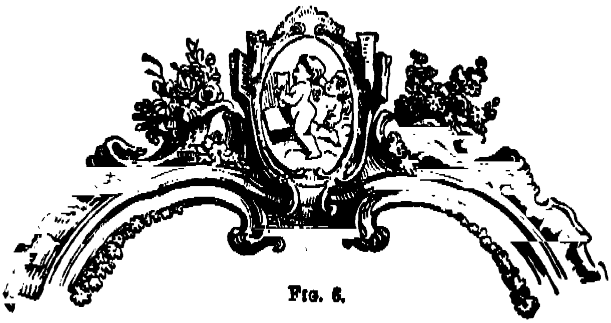
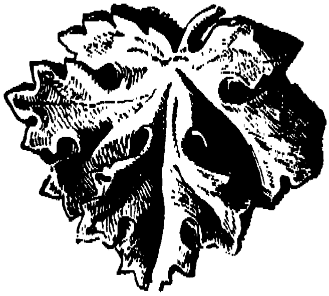


FIG. 6.



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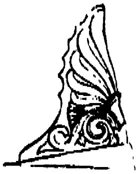


FIG. 8.

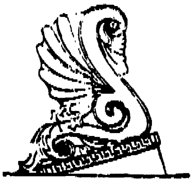


FIG. 9.

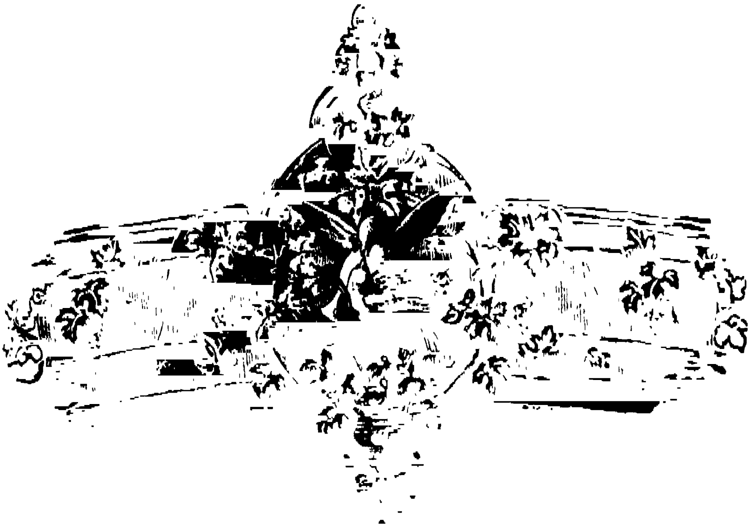


FIG. 10.

DETAILS CHIEFLY IN CARVED WORK.

THE CARPENTER (see Text).

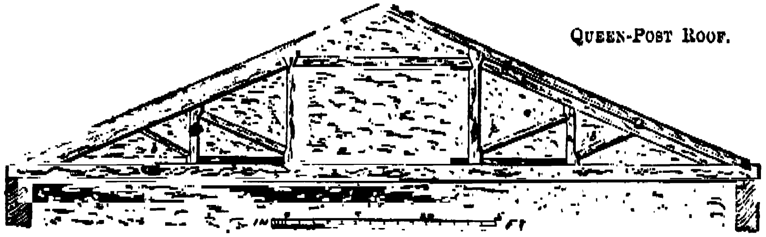

QUEEN-POST ROOF.

FIG. 1.

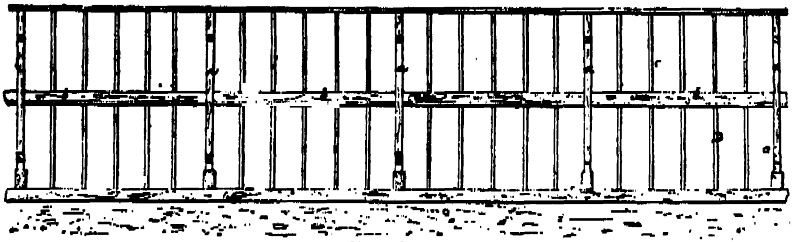
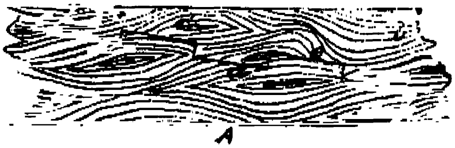


FIG. 2.—SIDE ELEVATION OF KING-POST ROOF IN FIG. 9, PLATE XVII.



SCARF JOINT.

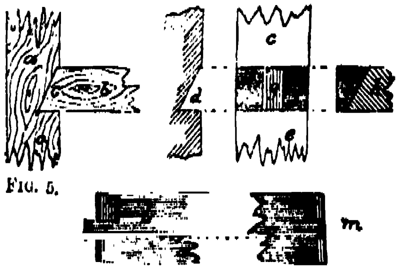


FIG. 5.

JOINT FOR HORIZONTAL WITH VERTICAL PIECE.

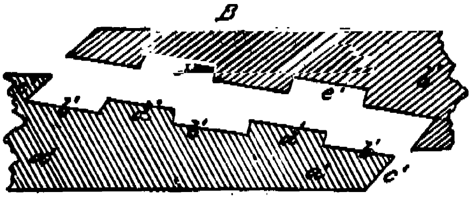


FIG. 3

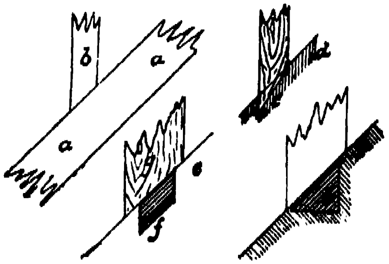


FIG. 6.—JUNCTION OF VERTICAL WITH OBLIQUE PIECES.

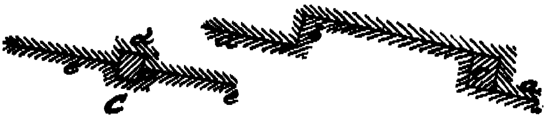


FIG. 4.—KEYS AND TABLES OF SCARF JOINTS.

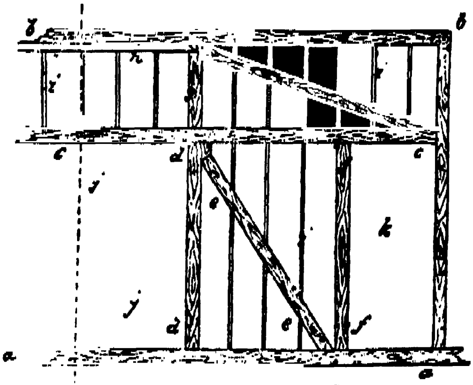


FIG. 8.—FRAMED AND BRACED PARTITION.

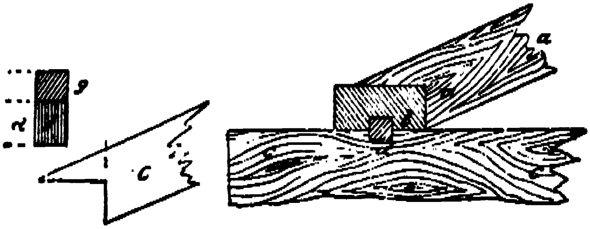
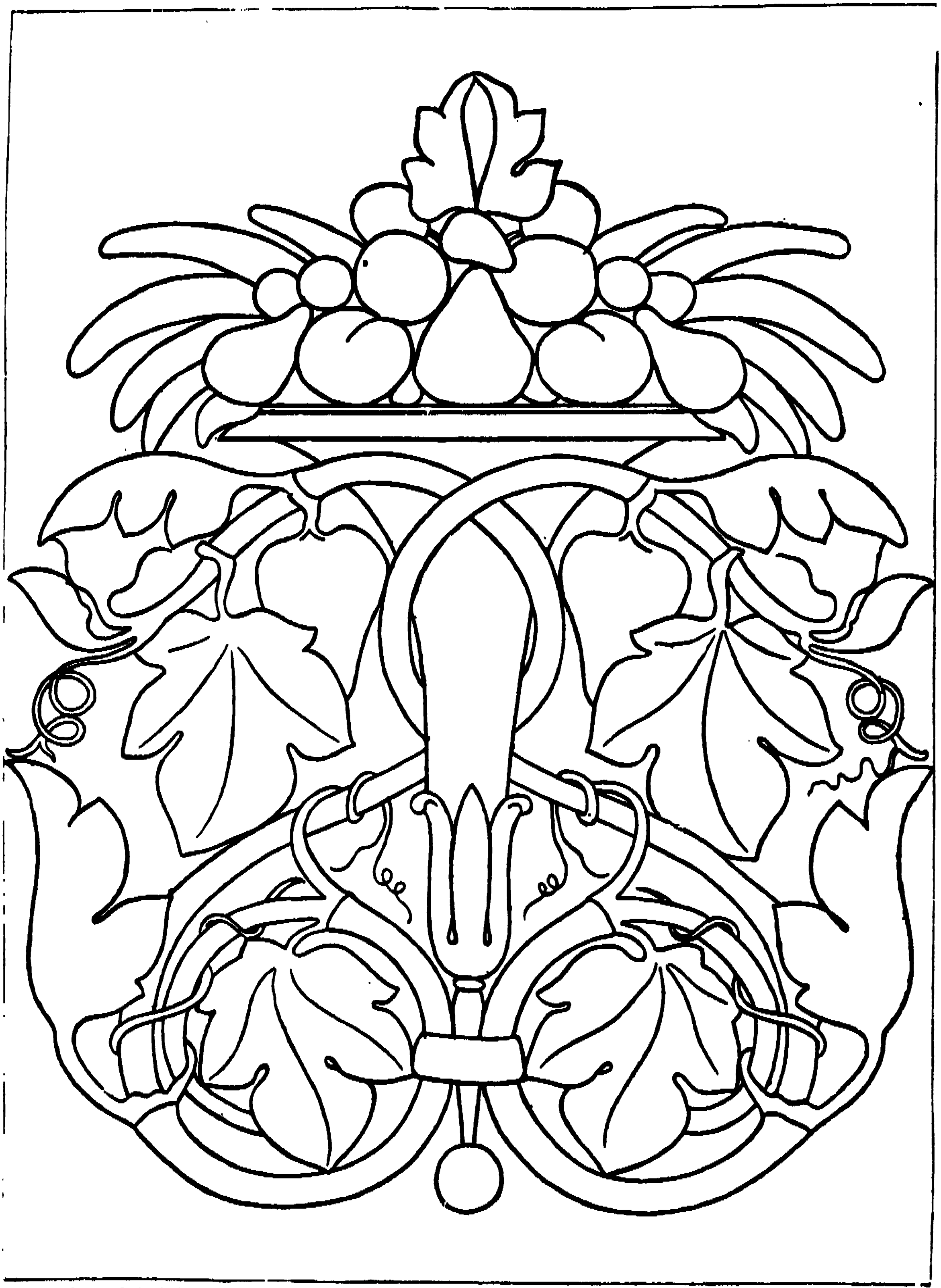


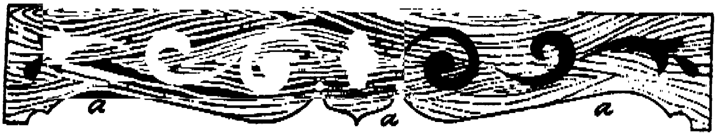
FIG. 7.—RAFTER, WITH WALL-PLATE AND TIE-BEAM.

THE ORNAMENTAL DRAUGHTSMAN (see Text.)



THE ELEMENTS OF DECORATIVE CARPENTRY AND JOINERY.

CHIEFLY FOR THE EXTERIOR WORK OF BUILDINGS, TIMBER STRUCTURES, ETC., ETC. (see Text).



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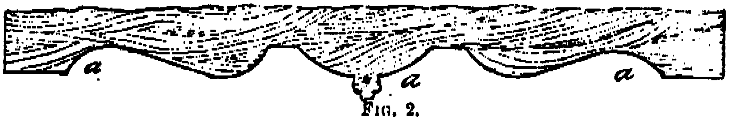

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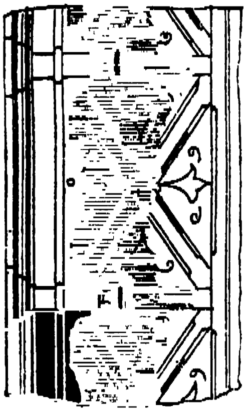
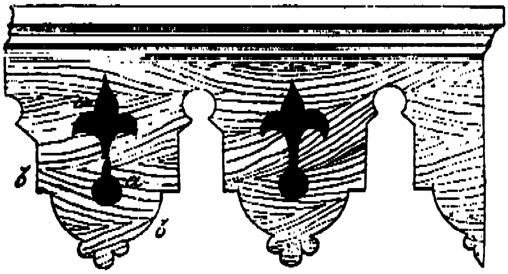


Fig. 3.



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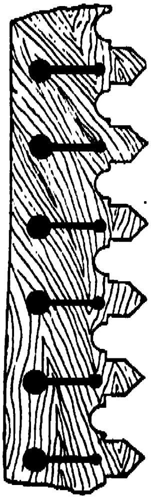


Fig. 6.

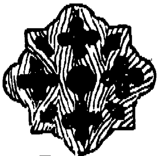


Fig. 5.

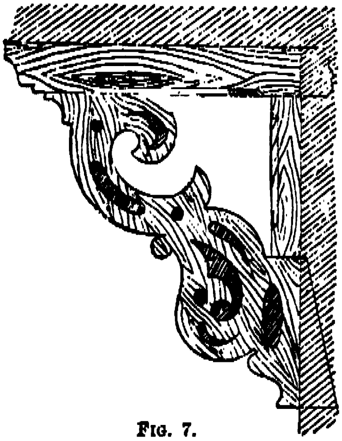


Fig. 7.

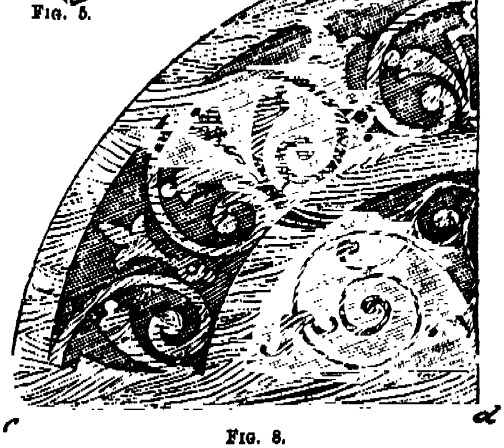


Fig. 8.

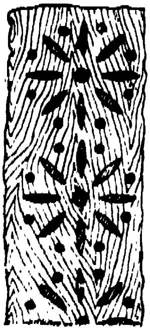
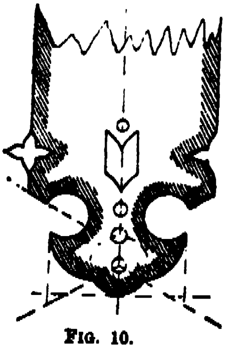


Fig. 9.



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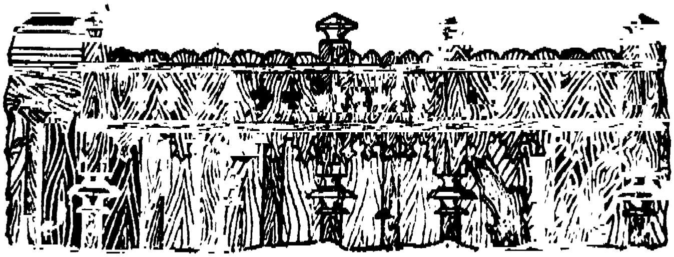
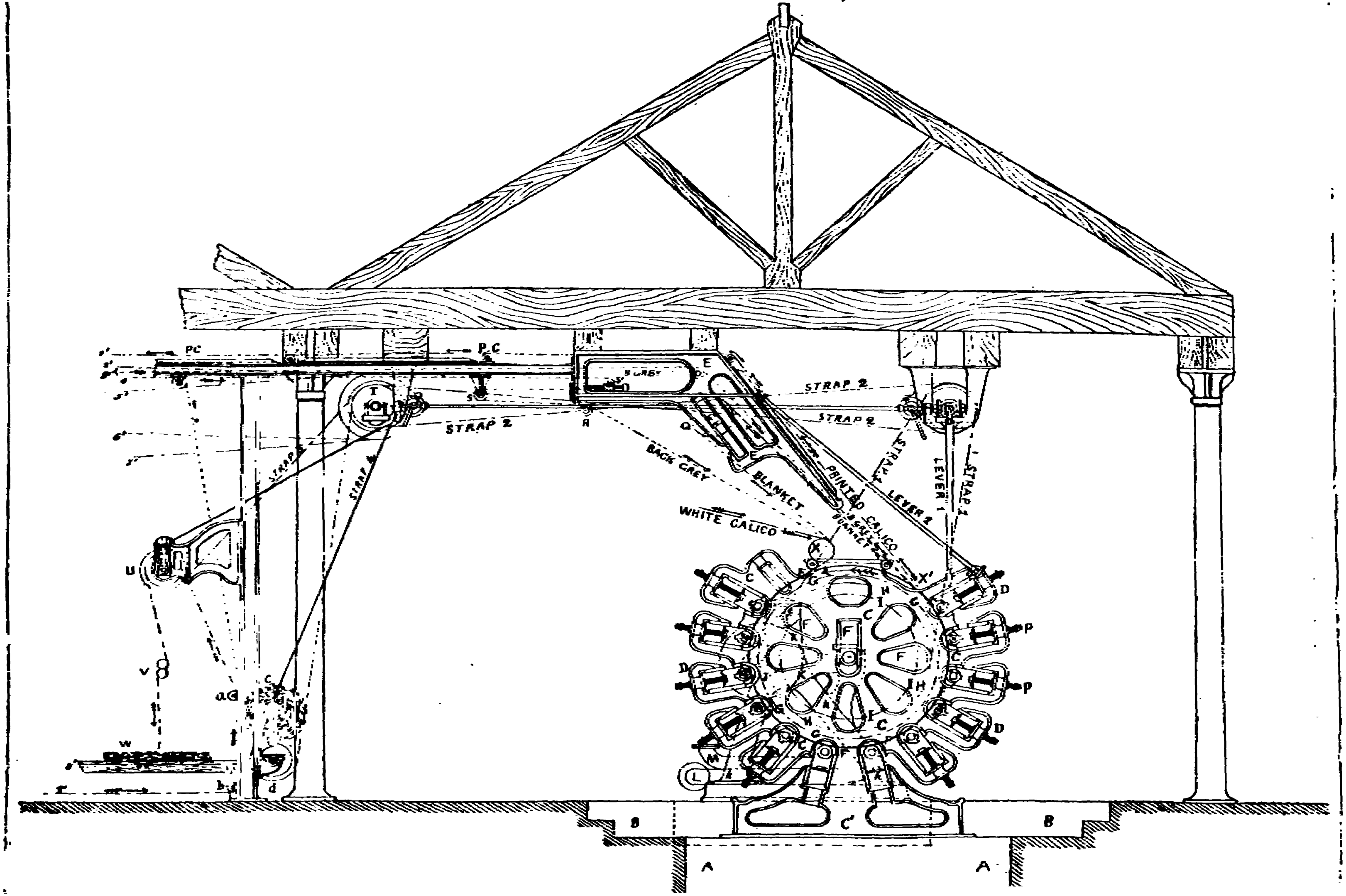


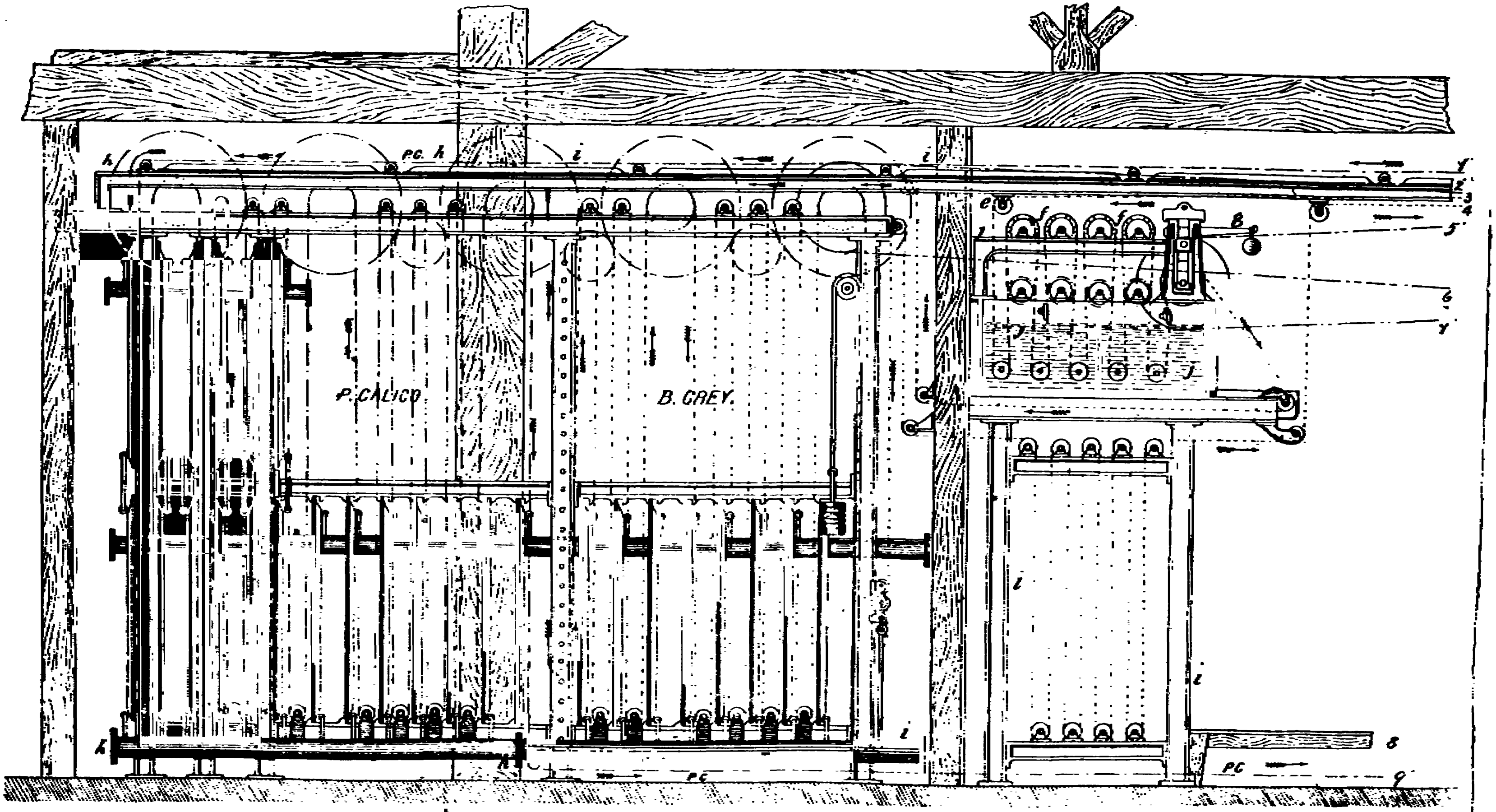
Fig. 11.

THE CALICO PRINTER (see Text).

Calico Printing Machine (*see Text for reference*).



Drying Apparatus for Printing Machine.



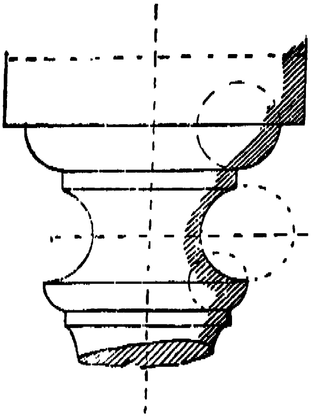
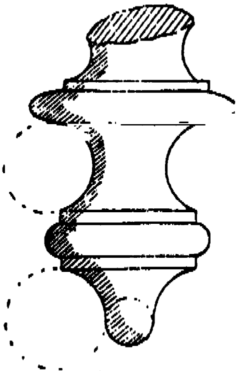


FIG. 1.



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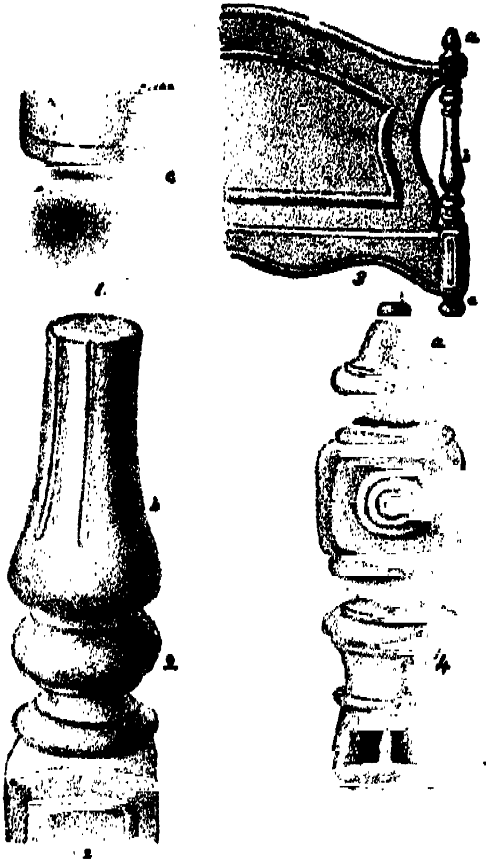


FIG. 3.

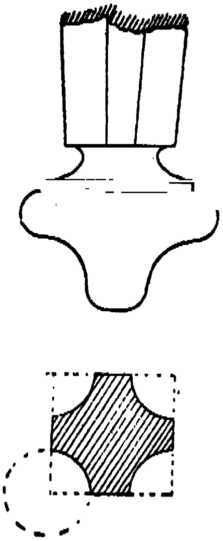


FIG. 4.

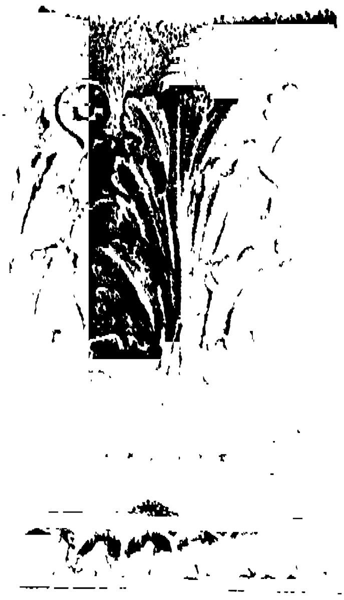


FIG. 5.

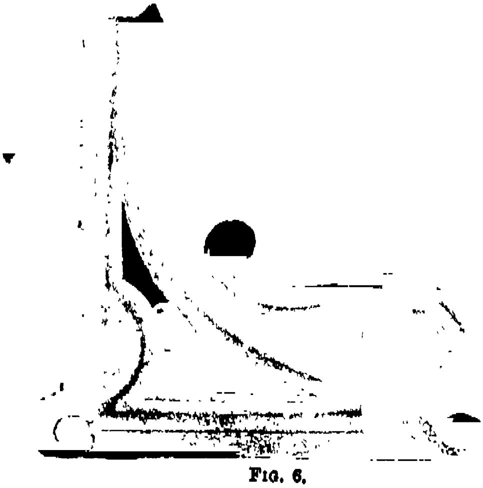


FIG. 6.

FIG. 7.

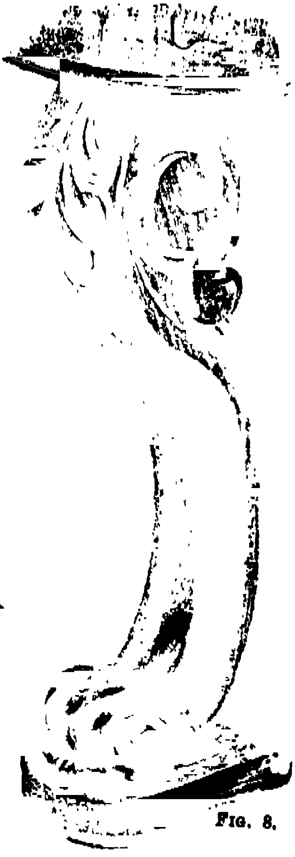


FIG. 8.

TECHNICAL EDUCATION

IN RELATION TO

THE PRESENT CONDITION OF OUR INDUSTRIAL WORK.

CONTENTS.

Practical Folly in Nationally Overlooking the foregoing Causes of Losses in Technical and Industrial Work—Condition of the Question of Technical Education in the Continental Countries; the Work of which constitutes the Grave and Serious Competition which we have as a Nation to contend with—Importance in this Connection of a Brief Inquiry into the State of Continental Technical Education—The Position occupied by our Country gives us the Best Opportunities to maintain our Supremacy as Technical Workers and Industrial Producers—Application of the Teachings of Science to Technical and Industrial Work—Technical and Industrial as Part of the System of School or Ordinary Education—Technical Instruction as open to the Working Classes in Schools, Colleges, and Institutes—Difficulty of the Problem—Work in the Extension of Technical Education to the Industrial Classes required to be done, in Addition to that effected by Special and Public Classes, Colleges, and Institutes.

Practical Folly in Nationally Overlooking the foregoing Causes of Losses in Technical and Industrial Work.

THOSE cases we have cited could be paralleled by others drawn from a very wide variety of technical and industrial trades and callings; so that if we add the results together, an aggregate is obtained which carries with it matter of the gravest importance to our national trade interests. The inference, and the only one open to be drawn from all this, is one which concerns every class, and no class more closely than that wide and important one for the members of which this Work is prepared, and for whom these lines are more especially written. We pride ourselves upon being a thoroughly practical people, and in most things we are so, or we should not occupy the high position in technical and industrial trades and callings we do. But in not a few things we lose sight of the practical element altogether, and become neither more nor less than mere dreamers. Is it not so in this particular case of the injury done to our interests as producers for the markets of the world by the two causes we have been now dwelling on—namely, the cheapening system, and the deceiving system of doing work? You can speak to no one of long standing but who at once admits and deplores that those two causes have done and are daily doing infinite mischief; that they act in themselves as not merely encouragers of the competition we have daily to face, but as the creators of new kinds of competition, and in new districts which would otherwise not exist, or but in an ineffective way. Yet, notwithstanding this frank admission, this deploring of effects, it seems as if the subject were one to be hushed up somehow, and as seldom as possible alluded to. No doubt it is a state of matters of which we have so much reason to be ashamed that our desire to hush it up and say nothing about it—at least publicly—can be in some way explained. We all admit it to be an "ugly" thing. But the results of it are uglier still, so far as our industrial interests are concerned. This mode of dealing with the subject is after all somewhat silly. It reminds one of the ostrich's way of getting rid of his enemy—hiding his head in a bush, and thinking that his exposed body is therefore safe from attack. But if foreign competition be the serious thing we say it is, surely any cause which promotes it or creates it must be no less serious. If doing bad work has done us so much evil in making competition so wide and effective, would it not be worth while—something truly practical—to try to do away with it? If good work made our trade originally, and if we have lost much of it through doing bad work, could we not regain our position by returning to the doing of good work, and that only? Surely this is worthy of a trial. At all events, in the discussions of the future on technical and industrial matters those two causes must be faced, whether we will or no. We cannot get rid of them if we would, and if we were wise in our own interests we would not if we could. Whether the fact that we do not face them now is caused by our being ashamed of them, is not our duty here to inquire. But it is our duty, in tracing out all the points connected with technical and industrial work, to declare clearly and honestly that those two causes are as important in their issues and influences as any other two which may be named. And in taking this position—unpopular though it be with many—we know that it is held by not a few, and those of the highest standing, who look far beyond the merely popular aspects of the question, and see clearly how the future will and must of *necessity* be greatly and gravely influenced by the way we deal or do not deal with all the difficulties which surround the question. And of these, the two we have named they look upon as not the least potent. In support of these views we could cite numerous opinions of the highest authorities practically concerned in the carrying out of our most important works. But this we do not deem necessary; it will be sufficient for our purposes, and will convey matter suggestive of the gravest consideration in connection with what we have given in this and the last few paragraphs, if we quote here the words of one who uses machinery and employs men on the largest scale. And these words are all the more pregnant with meaning when it is considered that they formed part of a speech addressed to the Institution of Mechanical Engineers, at the time we were sending this paper to press. The following are the grave words:—"He was sorry to say that he had heard the English name disgraced on the Continent owing to the bad work sent from this country. He said, let them go back to the old English way, and do everything better than every other nation." We have shown that we can do it if we will. The point cannot be too frequently and too strongly insisted upon, that the peculiarities of the position of technical and industrial work in this country in relation to foreign competition, and as a consequence the peculiarities of the position of technical education, are not brought into existence by one cause only. We have seen that there are many causes at work, and that these must be reckoned with—taken into account—and their influences as closely watched as we can watch them; and that we must use them for the furtherance of the true interests of the arts and sciences and the industrial and technical work upon which so much of the prosperity of our country depends.

Condition of the Question of Technical Education in the Continental Countries; the Work of which constitutes the Grave and Serious Competition which we have as a Nation to contend with—Importance in this Connection of a Brief Inquiry into the State of Continental Technical Education.

The allusion just made to the technical authorities of the Continent has a distinctly special value in the present connection. While fully aware of the value of the work done in technical education in this country, and of the high rank which our technical authorities take in the world of science and practice, we must not conceal from those of our readers who may not be aware of the fact that a systematic technical or trade instruction is in this country a thing, so to say, of yesterday. It is but a few years back when it could be said that its importance to us as a people was practically unknown to us, few only being alive to it. It has, therefore, only been very recently that the subject has been taken out of what was literally the region of theory—a thing considered by a few advanced thinkers to be good, and therefore talked about as a probable work of the future. In the early part of this Review we have had to make allusions to certain facts and circumstances connected with the history of trade work and industrial processes of this country. In these named, and in others which they will naturally suggest, will be found the reason why, of late years, the subject of Technical Instruction has been advanced to the position of one of those influences than which none can be reckoned as superior in potency as a means of raising the standard of attainment amongst our workmen; and in so raising it, by consequence increasing the value of their work, and giving us the best means of retaining that supremacy as workers for the world which we have seen belonged to us in former years, and that without almost a single competitor to enter the field of production against us. We are, therefore, now at last nationally convinced that Technical Education is a matter of pressing and immediate necessity.

But systematic Technical Education of those who are designed to be the industrial workers of the future, and of those who are already fully engaged in the actual daily work of production of the varied, almost endless objects of our arts and manufactures, is a work yet to be done, in a complete and comprehensive way. And while we have only, and that very recently, awakened to a sense of its national importance, a very different state of matters has existed in connection with it on the Continent.

But in approaching this subject—which, for obvious reasons, can only be glanced at in its leading features—let us endeavour to state the case fairly as contrasting the position of Technical Education on the Continent with that which it occupies in this country. For so much has been said as to what has been done and is still being done abroad in the establishment of a system of advanced, that is scientific education, in its application to the arts and industries, that to a large extent the public mind in this country is impressed with the idea that this education, if it has not been and is not now availed of by the working classes generally on the Continent, is so to a large extent. The truth, however, is—and it is distinctly emphasized by the Technical Commissioners in their Report—that this idea of the general, or even extensive application of a system of Technical Education to those engaged in actual industrial work, is erroneous. So far as our own experience goes, it seems that while the system of technical, that is scientific, education directly applicable to industrial work established on the Continent, is beyond all question of a high or complete character, it is taken advantage of chiefly by a class or by classes of young men nearly in all cases occupying a position in life above, and in many cases considerably above, the class or classes to whom the title of working men can be truly applied, and to whom the hours or times of attendance are quite a matter of indifference. And even where educational facilities of a high or advanced kind are offered at hours which apparently suit the convenience of the working classes occupied of necessity all or by far the best part of the day, it appears doubtful whether it can be said that these facilities are really taken advantage of by those working men. The one exception to this is in the case of technical education as applied to what is called artistic work, or now perhaps more frequently art manufactures, and in the case of France and Belgium. In those countries—and with certain modifications it is applicable to Italy—amongst the working classes engaged in art manufactures, "instruction" (to use the language of the Technical Commissioners) "of the most practical kind is diffused to an extent to which we have no parallel." It is right, however, to state that very great exertions have for some time been made, and are still being made, to place a system of education, the work of which will be directly applicable to technical industries, all over the Continent, and taking in all classes of the community. This is very marked in the case of France.

Notwithstanding what has been now said as to the hitherto and present adaptation to the circumstances of the working classes of its benefits, the fact remains that there has been established a system of technical education admirably adapted to give to industrial work the helps which applied science can so well yield. And this has been the case for a period dating from a time long before the public mind in this country was even attracted to the subject: certainly long before it was so impressed with its importance as to urge to public efforts to meet the requirements of the case. And now that we are not only determined apparently to do something practically, but have in reality done much in the establishment of a system of sound technical instruction, the difference between the position we occupy and that existing on the Continent, is this: On the one hand we have been only of late years beginning to establish a system of Technical Education, and have therefore been able to do but a very little in affecting beneficially the actual work of Technical Industry. Further, we are at the best only feeling our way towards the establishment of a universal system of Technical Education, which from the difficulties attached to it, will require years before our Technical Trades can possibly receive anything like the full benefit it is calculated to give them. Glancing round at the position of the Continent in regard to Technical Education, we see that the industrial arts have for many years been reaping more or less the advantages offered by the technical schools. If they have succeeded in but little else, the Continental peoples have had the start of us for a long time. But they have done more than this, and how much we have indicated in an early paragraph in this General Review. The Continental peoples have had for long a system at work which only requires extension to make it embrace all classes of the working men. We have yet largely to decide upon the precise character to be given to our educational system, and then to extend it over the whole kingdom. While, therefore, all Continental nations have more or less paid marked attention to the subject, as most closely and intimately concerning the welfare of their people, and those who have done little have far excelled us, who of all the European nations have done the least, to Germany must be yielded the palm of excellence for her efforts in this great work. To quote the words of one of our greatest English-speaking authorities on the general subject, Germany, as generally admitted, is "the best educated nation of the civilized world." She is "gaining a better industrial position daily, and there, instead of standing aloof from each other, and forgetting, as is too frequently the case in our own country, those great facts and those imperative duties which every statesman does and every citizen should recognize, the governing and the governed classes have worked together for the common good, and have given Germany, especially, a vantage ground in the universal struggle for existence and wealth, which is likely in the future to enable that country for many years steadily to gain upon all competitors." And although the following remarks by this authority have a special reference to the United States of America, those amongst us who know best what is our position in this vitally important matter will admit that, if they do not apply rigidly to ourselves, they possess, nevertheless, such cogent force that *they should at* *least suggest to us some considerations of the gravest import.* While Germany is thus gaining daily a remarkable position amongst the industrial workers of the world, the United States, remarks this high authority, is "retrograding in all that tends to give manufacturing pre-eminence, except in the ingenuity, skill, and enterprise of its people; and the one great, the vital, need of our people is a complete, efficient, and directly applicable system of technical instruction and of industrial training; if they are to avoid the successful and impoverishing competition of nations, which have already been given that advantage by their statesmen and education a generation earlier." While such is the position of Germany in this great question of Technical Instruction and Industrial Training, the deserved eulogy which it has drawn forth from those best able to form an opinion of the value of the work which she has done, is more or less applicable—in some respects more so—to other Continental nations; thus in Technical Education, France occupies a high position.

The Position occupied by our Country gives us the Best Opportunities to maintain our Supremacy as Technical Workers and Industrial Producers.

There would appear, therefore, from all that we have said to be but one conclusion—namely, that we can only bring back the trade which to a certain extent we have beyond all question lost, and can only keep what we have left, by doing the best work of which we are capable, by producing the best of goods which can be made. And while producing the best, with our command of so many resources, we ought, while giving our customers the best, to be able to give them, if not the cheapest, at least so cheap that they will, with their inherent goodness, always command the markets. And, fortunately for the future prospects of our trades, we are in the best possible position to do this. We have at all events the "start" of all other peoples. And more than this—and it is of the greatest possible moment to us—we have not merely all the natural and physical facilities for carrying on this perfect trade, but all the lessons of experience which years and years of a practical monopoly so abundantly and so well have given us. It is the very necessity which now forces us to be the producers of the cheapest, but which must at the same time be the best of goods, that has of late years brought our best thinkers and the most far-seeing of our practical men to deeply consider our position in this vital question—"how best to meet this competition with other peoples?" This is now, indeed, the paramount consideration of the day. Dependent as all our technical trades and industrial processes are upon *science* for the principles which define and decide their practice, the question is this: How can we most prudently and most wisely extend a knowledge of these principles—how best and cheapest apply them to universal practice? This, in other words, is what is known as *Technical and Industrial Education*. This may also be defined as turning the facts and principles of science to practical account; in promoting the interests—that is, increasing the value of the work—of daily life and business. Technical Education may thus be defined to be the systematic or scientific method of increasing the value of industrial work.

Application of the Teachings of Science to Technical and Industrial Work.

How best to secure a wide, or rather a universal extension of this technical education throughout all districts of the kingdom, has long been matter for the grave and earnest thought of those amongst us who are truly anxious that, as a nation of industrial workers occupied in the wide range which embraces every style of production, we should maintain the high position which we have so long held. This they clearly foresee can only be done by taking every and the fullest advantage of all the lessons which science, purely as such, is so well calculated to give. And not only in this way, but by availing ourselves of the accumulated stores of experience which have been handed down to us by preceding generations. And this also is rich in lessons as telling us not only what is to be done, but what is to be avoided in the practice of the future.

To secure such advantages in promoting the interests of all our industrial occupations, a variety of means have been suggested—a few only have been tried, and this with varied and varying success. And it need not be matter of surprise for us to learn that this success has been, up till now, far below the expectations of the sanguine, and has not come up to the hopes even of those who took a more practical view of the difficulties of the position. Much of the effort made has been merely tentative, for we have had everything to learn, and this arose of necessity from the very nature of the circumstances in which our industrial workers have been placed. At the present time we are therefore far from having attained to the standard of perfection, if that indeed be ever reached, seeing that the arts—because the sciences on which they are based—are eminently progressive, and much in science itself has yet and will apparently ever have to be learned. Still we are nearer to the point of perfection in technical knowledge than we were some years ago. And the best hope that we shall make much greater progress in the near future than we have done in the late past, lies in the fact that as a people we are becoming daily more and more rapidly impressed with the conviction that, if we are indeed to maintain our supremacy in industrial work of all kinds, we must avail ourselves of the aids by which that industry is promoted in its best and most advanced interests.

Technical and Industrial as Part of the System of School or Ordinary Education—Technical Instruction as open to the Working Classes in Schools, Colleges, and Institutes.

And precisely in proportion as this conviction is becoming more and more fixed in the national mind, do we find that earnest endeavours are made to arrange our general or popular educational system so that its teachings will be closely applicable to the production of industrial work, and to associate with it, and draw to its help, every influence of a favourable kind calculated to aid it. That we are now making great efforts to introduce a practical system of technical instruction amongst our workmen is one of the circumstances most gratifying to those who with a wise foresight are trying to indoctrinate the public mind with a sense of the vital truth that to hold our own in work we require all the aids which science can give in showing us how to improve that work. The Royal Technical Commissioners, of what has been already done and is now being done daily throughout the country in this direction, give a very complete account. To their report we refer the reader for details, space precluding us from giving them here. Suffice it to say that everywhere our manufacturers, our engineers—all, indeed, engaged in the leading industries of the country—are, no less than the general public, becoming rapidly impressed with a sense of the vast importance of the subject, and are making efforts of no ordinary kind to give facilities for imparting a sound technical education to the classes who will be benefited by it. The difficulty of the task before us does not, we have every reason to suspect, lie in the way of establishing the educational system required; money enough and energy enough in its application will not be wanting, as they never are lacking in any movement when once the public arrive at the conclusion that its work is absolutely necessary to be done. The real difficulty we apprehend in the solution of the problem before us is not therefore in the establishing of a good system of Technical Education, but in applying it practically to the circumstances of the daily work and lives of the working classes, so that they can make it directly and immediately useful to that work. This opinion—and it is held completely, and shared more or less so, by very many who are entitled to give expression to it—is based upon sound knowledge of what our working-classes are, what the circumstances of their lives, what their habits and modes of thought and action are.

Difficulty of the Problem.

But it is not the least puzzling point presented by the problem before the nation, that its solution every one sees to be immediately required. While "the grass grows the steed starves"; and the practical application of this proverb to the circumstances in which our technical and industrial work is now placed is obvious enough, in face of the great and ever increasing competition with which our trades and industrial callings have to contend. This consideration, however, must only move the nation to make up by the earnest work of the future for the grave errors and omissions of the past. Nor must the public mind overlook the fact, and be unprepared to deal with it, that the problem of how best to adapt a system of technical education, the establishment of which is in reality the simplest part of the work before the nation to the peculiar circumstances of the working classes, will of necessity open up many other problems—certainly more than one—having a more or less direct connection with other social conditions. So dependent, as it will be found, is one department or circumstance of working life upon another. The solution of the intricate problem thus before us, in view of interests involved vital to the welfare of the nation, is neither more nor less than simply imperative.

But this great work in itself is so many-sided, embraces so many considerations, requires the doing of such a variety of work in such a variety of ways, in order to meet the requirements of so many classes, and is, as a systematic whole, so new to us, that it is only reasonable to suppose that it will of necessity be a long time before we can formulate a good and thoroughly efficient system of National Technical Education. And this, to be of really practical service, must be made as closely applicable to the main object in view, and as wide and comprehensive in its grasp of, or the hold it will take upon, the people, as is the system of primary or elementary education now existing amongst us.

Work in the Extension of Technical Education to the Industrial Classes required to be done, in Addition to that effected by Special and Public Classes, Colleges, and Institutes.

It does not concern us here to enter into details connected with the direction in which attempts are being made to establish a system of National Technical Education by means of such agencies as schools, classes, colleges, and institutes of science and art. It is not here part of our duty to consider how far the principle upon which such educational establishments are based, and the means by which they can be rendered more efficient than they are, are calculated to yield the largest amount of practical work for the great cost which their working involves. All that our present purpose calls upon us to show is, that whilst those private schools and public institutions can do—have done—much, there is more yet to be done. And this, with their general principle of operation, their practical organization, and their limited extension—exceedingly limited when we consider the area which ought to be covered by them—we fear they cannot, at present at least, directly do.

The very fact that the establishment of those public institutions is of necessity a costly undertaking, that the system they propose to work out is meanwhile tentative or experimental, at least to a very large extent—for we have everything yet to learn in this the new direction of national effort, —the very extent of the field which is to be occupied before the classes it is desired to benefit can all be brought practically within its sphere of operation,—makes it almost a matter of certainty that it will be years before all the good they are capable of doing can be effected.

But while the means to secure those advantages are thus slow of attainment, this gravely important position must never be lost sight of, that the necessity to give them to our industrial workers is immediate and most peremptory. This, in fact, is becoming daily more and more decided. For the very causes which we have named as influencing injuriously the future of our trade are increasing in numbers and potency every day. The competition of our rivals in business is becoming every day keener and more earnest, while the more number of the competitors is marked with the same feature of steady and rapid increase.

We have said that while public technical classes can do much, they cannot, as we now see, do all. It is, indeed, questioned by some whether, after all, they can really do the most important part of the work which now lies nationally before us. There are not a few thoroughly practical and prudent men who maintain that the real benefit of such public institutions is to direct the attention of working men, and those connected with technical work, to private sources of knowledge, and to incite them to that close and earnest study of books, and the clear and close personal discussion of technical points with their fellow-students and workfellows —which latter element a very eminent scientific, as well as a thoroughly practical authority, says, does more to give practical knowledge than all the attendance upon schools, colleges, or institutes, which might be given.

It might, indeed, be easily enough shown that the practical result of all technical teaching through the medium of lectures, or the more direct and individual teaching of the technical class, is to help the student to *teach himself*, or at all events to assist him in taking the fullest advantage of the teaching of others in the special subjects he takes in hand. So far as scientific lectures are concerned, they are not the end itself, but only one of the means to an end. If the lecture inspires the student chiefly, if not wholly, with the idea that what it gives is all that he requires in the way of education, it fails—and in a way which does infinite mischief —in effecting the object for which it confessedly owes its very existence. Scientific teaching, or rather, so far as the student himself is concerned, listening to what is being lectured upon, is not education. It is only an incentive to its being properly carried out. Hence so many practical authorities object altogether to scientific lecturing—purely as such —forming any part of technical teaching. This, however, is an extreme view. The lecture proper—for there are *lectures* and *lectures*—may be of use, often is, and can, we think, be made still more effectively useful. If it does nothing more than direct the student to the existence, so to say, of a country rich in a wide variety of products ready to his hand if only dug and looked earnestly for, it will be of value. The student must *himself* travel to and through the dominion; must look for, in order to find, and finding, keep or make his own, all the treasures which the field of scientific knowledge so richly possesses. *Individual* study must thus be given in order to gain individual benefit. There is no delegation in the work of education. If it is to be done so as to be of true practical —that is, paying—service to the individual, it must be done alone, by him and for himself. And the greater the service he does in this way to himself, the greater the good he in turn and in time does to the community at large.

THE ORNAMENTAL WOOD WORKER AND DESIGNER,

In Carpentry and Joinery, chiefly for Exterior Work.

BEING ONE OF THE SUB-SECTIONS OF THE PAPER ON "FORM AND COLOUR IN INDUSTRIAL DECORATION."

CHAPTER I.

Introductory.

THERE are certain principles of "Ornamental Drawing and Design" which are common to all classes of "design," whatever be the material in which the designer works. What those principles are, the authors of the papers entitled "The Ornamental Draughtsman" and "Form and Colour in Industrial Decoration" and "The Cabinet Maker" have endeavoured to make clear to the intelligence, we trust, of the most youthful of our readers. If the instructions there given, and suggestions and hints of the most practical character, be closely attended to and followed up, the pupils will come to the departments with which the present series concerns itself, thoroughly prepared to apply their knowledge to the work of design in the ornamentation of various materials used in the constructive arts. As the branches of ornamental drawing, and the principles affecting the application of form and colour in design, explained in the papers above alluded to, are common to all ornament as applied to wood, stone, or metal, so the "mouldings" of which in the paper entitled "The Ornamental Worker and Designer in Mouldings, applicable to all Constructive Materials (being one of the sub-sections of the paper entitled 'Form and Colour in Industrial Decoration')" we have given examples, may be said to be applicable to all ornamental construction. This is specially true of those branches of handicraft work connected with what may be classed as the building trades, and is yet more especially applicable to those concerned in domestic buildings. In this category we include those connected with interior work as well as those whose labours are confined to what may be called the outer shell of the building. So that in addition to the carpenter, what we purpose in the present series of papers to give under the head of "Ornamental Wood Work" will address itself also to the joiner and the cabinet maker.

Chief Characteristic of the Work of the British Carpenter Sound and Solid Workmanship.

All writers on the subject of construction agree in according to the British workman the highest merit in giving workmanship of the best kind so far as stability, solidity and lasting qualities are concerned. This is known to all as "first-class work"; sometimes somewhat facetiously—borrowing a term from the well known ships register at Lloyd's—"'A 1' work, Sir." As a rule, this character for giving sound good work is eminently well deserved by handicraftsmen generally throughout the kingdom; although it is but right, by way of such warning as a record here of the matter may give, to state that there have been of late years whispers abroad that if the workman has not lost the "cunning of hand and eye" which distinguished his forefathers through a long, long range of years before him, he is not always ready to do his work in the same spirit which distinguished them, prompting them to give the very best they were capable of.

But while all writers have been unanimous in giving the highest praise to the work of construction in this country, they have not been, and are not now by any means, so as to the claims which this work possesses to be considered beautiful or pleasing to the eye. In construction, purely as such, we excel, or can excel if we choose to do so; in design of an ornamental character we are so far from excelling that we display but very few evidences that we even know what it means. Such is the verdict as given on this point by the great majority of those who claim to be, and have indeed good credentials to be, considered as high authorities on the subject. Without at all pushing inquiry into the field of facts as they exist around us, to see whether they would justify a verdict so disheartening as this, we may remark that it must be taken with a reservation before it is admitted to be correct. We think, for example, that it applies with greater force to some branches of work than it does to others, and that as regards one or two it does not apply at all. And this for the reason, easily and amply enough proved by facts, that in point of design as well as in construction, our workmen in certain branches will rank with the same class of workmen met with on any part of the Continent.

Contrast in Ornamental Characteristics of Constructive Wood Work of the British with the Continental Carpenter or Joiner.

For the reader will take note that in this point of excellence, or the opposite -- deficiency in design, our workmen are always contrasted with the workmen of Continental Europe; of whom the French are usually said to be the highest in the scale of creations of beautiful objects — that is, good designs. But if the French workmen are thus considered by many as bearing away the palm of excellence in design, we nevertheless maintain that there are some branches in which our workmen in this respect are almost, some in which they are quite equal to them, and a few in which they are unmistakably superior. We do not here quote instances in proof of this. Occasion will be had again to refer more specially to the assertions we have made, in considering the details of certain departments of work. We meanwhile merely content ourselves with stating our opinion, which we believe to be amply justified by facts, and we are glad that we can do so, as to praise is, we think, always more delightful than to blame.

But while this is so, we fear that those writers who mete out censure to our workmen as failing in ability to design—not that they love to censure, but simply because they feel compelled to do it—are more than *justified by what are the facts of the case in, we are constrained to say, more than one branch of* constructive work. What those branches are we shall have occasion to specify as we proceed; meanwhile, we presently name one branch, being that to which, *in extenso,* we purpose to direct the attention of the reader, as affording ample scope for the censure of even the most severe of critics.

The External Timber or Wood Work of our Various Structures, chiefly Domestic or Civil, as Certain Classes of Public Buildings, characterised by an almost Total Absence of Ornamental Features.

The external parts of buildings made of timber are here considered as those capable of receiving all the value which ornamental design is so well calculated to give to them. In opening up this subject, and noting in what direction this censure is, and so amply, justified, we labour under the disadvantage of having but comparatively few examples of actual construction in this country, which would act as contrastive specimens, from which we could illustrate the faults or deficiencies of the one by the good points of the other. For it is but a simple statement of the fact, that of ornamental wood work in the branches of construction we have generally referred to, there is with us an almost absolute lack. From "Dan to Beersheba," from John O'Groat's house in Scotland to the Land's End in Cornwall, it might be said with almost perfect accuracy, the "land is altogether barren." It is only here and there, and like angels' visits, few and far between, that one meets with attempts at applying design to those parts of ordinary and general construction for which it is specially designated as adding greatly to their beauty, while in no way interfering with their utility. We say attempts are made; but it is doubtful whether this term, with what it involves, is truly applicable. Such as they are, they look vastly more like matters of mere chance, springing up one knows not how, emanating from one knows not what. Of most of these we fear it may be said, as was said of Topsy, or rather as Topsy said of herself, in the well-known novel, "'spects I growed."

Richness in Ornamental Design a Marked Characteristic of Continental Timber Work in Domestic and other Structures.

To know what design in wood work is, as applied to the ordinary everyday structures in which timber is used, we require to cross the Channel and take a wide survey of the various countries of the Continent. That survey has been made, to an extent not often granted to dwellers in this country, by the writer of these present pages; and he can with all truth aver that till he became practically acquainted with what almost every workman in wood—even nearly in the smallest village—on the Continent can do in ornamental wood work, he had not the slightest conception of the fine medium which ordinary wood construction affords for the exercise of design in ornament. Privileged to extend his researches over many districts widely separated from each other, and making the subject one of special inquiry and study, he was surprised and delighted with the examples he everywhere met with. And this excellence in wood work ornamented was not confined merely to what were, in point of fact, elaborate combinations of timber "in the large," but it was met with in every detail, however minute. Nor was it a feature of this department that its work was displayed in structures which were, from their size or from their cost, considered as important works. It was met with in structures of the smallest and indeed of the humblest kind. Everywhere examples were met with in this less ambitious class of work in which it was evidenced, beyond a doubt, that the workman, out of a pure love for the elegant and the pretty, if not for the truly beautiful, would not erect his structure, however simple, without throwing out upon it some marks, more or less striking, of this love. Indeed, in many out-of-the-way corners the writer met with structures which the workman had erected, with but little chance of many eyes—save his own—looking upon it; yet upon which he had lavished a true wealth of artistic design. And this not only in the general features or *tout ensemble* of the structure, but throughout all its details. Not a few cases of this kind were met with, showing beyond a doubt that the workmen had somehow got such a love of design that they could not help displaying it, even in work which, with us at least, would be classed almost as of the meanest. And be it remembered that the workmen who produced many of these fine designs were, in every sense of the term, but what we here call "ordinary workmen."

The True Feeling in the doing of Ornamental Work which lies at the base of all True Artistic Work.

And it is worthy of note that the feeling which prompts the workman abroad to do beautiful work in the way we have alluded to lies at the root of all artistic work. He who is possessed of the true artistic spirit does beautiful work because he likes beautiful things. And he does it with as much pleasure and earnestness if he knows no one is ever likely to see it but himself. The notion of an audience, or rather of a number of spectators, never seems to concern him. He is not thinking of applause, or of payment for his work; whether he receives the one or pockets the other, or whether he receives neither the one nor the other, he does his good work all the same. Paraphrasing a well-known phrase, we may say of him that he stands as if saying, "Here I stand,—I can do no other than I do." And artistic work in the true sense of the term will never exist amongst us as it ought to exist till this spirit spreads widely amongst and influences our workmen. It is only the love of the beautiful which prompts to the execution of work considered in and by itself beautiful. And although it is quite legitimate for a workman to try and "better himself" in the world, as the phrase goes, by having a knowledge of design, he may rest assured that if this be his only motive he will never occupy aught but a very subordinate position in the ranks of designers. As the doing of duty in every rank of life is the first consideration—come what come may, this and no other—so, unless the art workman be imbued with a love of the beautiful for the sake of the beautiful, he may profess to be a designer, but a designer in the highest and truest sense of the term he never will become.

Exceptions to the General Lack of Ornamental Features in our Timber Work.

In saying, as we have already said, that of work of this kind our country is altogether barren, we did not intend to convey that we had purposely or otherwise overlooked the fact that there are some exceptions to the statement. But we do not hesitate to say that these are truly exceptions, and that the rule is as we stated it. Our position, in point of fact, is precisely that of the writers we have alluded to, who maintain that while our workmen excel in construction, they fail miserably in design. In averring this it is not, of course, understood that they deny, or would if put to it deny, that there are some—very many—workmen who show power in design as well as skill in construction. All that they mean—and it is much—is that as a rule their criticism is amply justified. So, in like manner, while admitting, and gladly, that there are not a few specimens of fine designs in woodwork to be met with amongst us, we do aver that as a rule there is an almost universal lack of it. Indeed, keeping to the general class of ordinary, or if the reader prefers it, common work, and comparing it with the same class abroad, this might be said with all safety—that the art of design in wood, as applied chiefly to external work, does not exist in this country. And this does not ignore the fact that there are specially good examples designed by able architects for special and generally costly work. Nor does admission of this fact in any way disturb—certainly does not destroy—the rule as we have stated it in the baldest, plainest way.

Popular Artistic Taste, or the Lack of it, the Cause of the Low Condition of our Timber Work, ornamentally considered. —Its Reaction on the Practical Workers.

As we have said, its truth can be proved any day and anywhere—proved negatively, if not positively. Only that the truth is not popularly observable, as in the popular mind there does not exist any recognition of the fact that a want exists. What one does not know of or think about one does not wish for. And if we do not miss examples of beautiful work around us, that in all probability arises from the fact that we do not know what the beautiful is. This, indeed, is one of the most cogent reasons which exist for what is called art education. This does not consist, as some seem to think it does, in merely teaching pupils the rudiments of the art, or even going far beyond this, but it includes a cultivation of the beautiful, a desire to have it and to exercise it amongst the people generally. In truth, this cultivation of a taste for the beautiful is that on which a desire to be able to execute beautiful work is based. For the very first step we must take in the acquirement of any branch of knowledge is to become acquainted with the fact that we are ignorant, and that it would be the better for us if we had knowledge. The first step to acquire anything is to be aware of the fact that we lose something by having it not. There is no satisfaction so supreme that things are right like the satisfaction which the truly ignorant possess. We make the first step in getting them to acquire all the inestimable advantages of knowledge when we get them to perceive that they are losers by the lack of it. We may educate, as we term it, any number of art workmen by the rules of art, and get them to excel even in the details of its practice. But this is not art in the highest sense of the term, any more than it is knowledge which so many scholars in our schools have when they leave school crammed only with facts which they may be able to repeat well enough, but of which they can make no use, simply because it is only the mere faculty of repetition or of memory which has been exercised, not the intellectual faculties which grasp the true meaning of their "lessons."

Recent Improvements in the Popular Taste in regard to Beautiful Work.

Much of this which we have said lies really at the root of the movement known as the cultivation of a taste for the beautiful amongst the general population—that is, amongst those who have no practical or business connection with artistic work as a calling, nor are even likely to exercise it as an accomplishment. This cultivation of a taste for the beautiful has been and is still advocated by many, on the simple ground that by having it they will be all the higher in the scale of civilization; and possess a new intellectual, and in itself a pure pleasure—leading to a desire to leave and to dislike the lower and grovelling pursuits and tastes which in truth affect so many of our people.

The Drawing Board and T-Square, although Separate Pieces, yet practically form but One Appliance.

And first as to the drawing board and the T-square, which, although two distinct and separate appliances, may be looked upon as but one, seeing that the board is useless for practical purposes without the T-square, and *vice versâ.* These two may be called the primary or essential appliances of the draughtsman. Different sizes of drawing boards are required for wide practice; but for the beginner, one fifteen inches long by twelve wide will be sufficient. It may be and is made of different kinds of wood, as fir or pine (of these red pine is the best), Spanish mahogany, or apple or pear tree wood. But of whatever variety of timber it is made, it is essential that the wood used be thoroughly well seasoned. Many boards are made of badly seasoned wood, and the result is that they warp and twist so much that they are useless for the doing of correct work. The best plan for the young draughtsman to secure a drawing board of well-seasoned timber is to purchase it from one of the old-established mathematical instrument makers. They keep a stock of timber on hand for a long period before making it up into boards, and any which do warp, or give signs of warping, they lay aside for adjustment when fully seasoned, and until they are so do not offer them to their customers. Established houses have a reputation to lose, and that the young draughtsman may rest assured they will not imperil for the small profit they could make by selling a defective board.

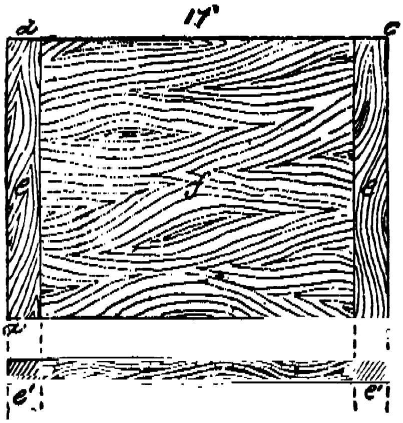


Fig. 1.

piece *f*. There are other methods of constructing the drawing board so as to prevent it changing its first accurately given form; but at present we give only the simplest and the most generally used mode of construction.

Not only must the surface of the board *a b c d*, fig. 1, be absolutely flat, no one part of it rising above another part, but it must be perfectly "square." That is, the ends, as *a d*, *b c*, must be exactly at right angles to the sides *a b*, *c d*. Any deviation from this condition gives rise to a proportionate inaccuracy of adjustment, which will show itself in every drawing done on it. All boards, when made, are accurately adjusted so as to be "square" or "true," as the technical phrase is, but if kept in stock for a considerable time they are apt, even when what has been thought to be well-seasoned wood has been used, to warp a little, and should be adjusted before being purchased. A very simple test will enable the draughtsman to see whether the board is accurate.

Description of the T-Square.

The T-square, which is a constant companion of the drawing board, is so called from its shape, which closely resembles that of the letter T; the head or stock *a a*, fig. 2, being at right angles to the blade, *b b*. This blade should be of the same length as, or a little over, that of the board, as *a b*, *c d*, fig. 1. As in the case of the board, it is absolutely essential that the T-square should be, what its name, indeed, assumes it is, namely square, otherwise it does not deserve the name. That is, the head *a a* must be exactly at right angles to the blade *b b*, or *vice versâ*. The head and blade are so secured together that the head *a a* can be slid or moved along any of the edges of the board, while the blade *b b* shall lie quite flat upon the surface in contact with it throughout its whole length, and so also that the part of the head in contact with the board shall lie flat against the edge throughout its whole length. There are more ways than one of securing these conditions. The simplest way to connect the stock or head of the T-square with its blade is to screw or otherwise fasten on the end of the blade to the central part of the upper surface of the head. But a neater way is illustrated in fig. 2 at *c*. In this the end of the blade *b b* is finished with a dovetailed part *c* (see "The Joiner" for illustration of dovetailing), this being let into a correspondingly shaped part cut out across the upper face of the head or stock *a a* at its central point. When the two are placed in position, the part *c* is secured by two small screw-nails, or glued or cemented. A sliding surface or shoulder for the head *a a* to slide along the edge of the drawing board, as *a b* or *b c*, fig. 1, is obviously provided by this construction, as the thickness of the blade *b b*, fig. 2, is always much less than that of the head *a a*. It results, therefore, that when the end *c* of the blade *b b* is let into the head to its be "flush," or on the same level, the stock or head being so much thicker than the blade, a portion of the thickness of *a a* will be below the blade *b b*. This position gives a sliding surface to the head, for contact with the edges of the drawing board. But in more carefully constructed T-squares, a special sliding edge is formed in the head or stock *a a* by cutting or ploughing out a deep "rebate" (see "The Joiner"), as at *d e*, showing part of the edge of the blade *b b*. An end view of the stock is shown at *f f*, with the end of the blade let into it as at *g*. A side view of the T-square as a whole is shown at head *a'* and blade *b' b'*, the rebate being shown in head.

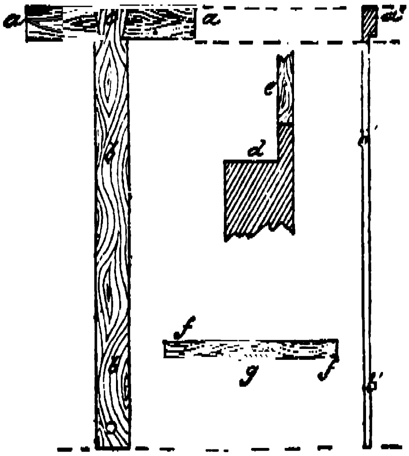


Fig. 2

The Drawing Board and T-square in the drawing of Lines parallel to and at right angles to each other.

Lines parallel to the sides *a b*, *d c* (fig. 1) of the board, or others parallel to the ends *a d*, *b c*, or parallel to one another, can be drawn by the aid of the T-square (fig. 2), and obviously lines at right angles to each other in these directions, and then transferred by pencil to any sheet or piece of paper lying upon and secured to the surface, *a b c d*, of the drawing board. But the drawing of such lines is greatly facilitated, and other lines at certain angles to those can be readily drawn, by the use of other and simpler appliances. These will be explained presently; but we now have to give a few remarks upon the paper, and the methods in use for securing it to the board so that it shall remain fixed in one position from the commencement to the finishing of the drawing which is in hand.

The Classes or Kinds of Paper used by the Draughtsman or Student.

There are two kinds of paper which the young draughtsman may use. The first, for superior drawings, is that known specially as "drawing" paper. It is made in various sizes, each size being known by a distinctive name—as "demy," "royal," "imperial," "antiquarian," etc. This kind of paper is made by hand, and is therefore very expensive, and is generally known as "Whatman's," from the name of the maker, who gained a high reputation for the making of paper of this class. There are other makers; but the draughtsman can easily see by whom any paper offered him is made by holding the sheet up to the light, thus making the water-mark name of the maker obvious. Drawing paper of this class is made of two kinds—one with a highly polished or glazed, the other with an unglazed and somewhat rough surface. Some draughtsmen prefer the glazed or smooth-surfaced, others the rough. We should recommend the young draughtsman to use the rough or unglazed. The surface of this takes a better bite of the pencil, and takes on ink and colour much better than the paper with highly glazed surface.

draughtsman is machine-made, woven, or web paper. This is often described as "cartridge paper"; although machine or web papers are now made of a kind vastly superior to the old cartridge paper, and those kinds are moreover now very moderate in price. It is much cheaper than hand-made. though not nearly so strong, and is therefore apt to slit and tear up when fastened by the stretching method of securing it to the board about to be described. It may be had in almost any length, being made in a long web and rolled up. The width is also very considerable. Although inferior in quality to hand-made, it is quite good enough for the young draughtsman to commence his practice with, and is indeed largely used by practical men for the making of rough or first drawings, or sketch drawings, and also for much of the work of working or large-scale drawings. There are, of course, different qualities of this class of paper, and the best is not so very inferior to hand-made, so that it suffices for a pretty wide range of work in the drawing office or school. A still cheaper and perhaps more easily purchased class of paper may be used by the young draughtsman for his early lessons. This class is made up of the different varieties of printing papers, some of which are very strong, and afford good surfaces for taking on colour and ink and giving a good bite to the pencil. We have known young men not blessed with a well-filled purse do a vast deal of excellent designing and sketching work, and even of well-finished drawings, with that class of paper—known sometimes as "tea" paper, being that used for the wrapping up of their medicine bottles and packets by druggists. Sixpence will purchase a pretty good stock of this, and being by no means a poor quality of paper, it will be found useful for a variety of purposes—writing as well as drawing—in the career of the technical student.

The Different Methods employed in Fastening the Sheet of Paper down to, or Securing it to the Face of, the Drawing Board—Temporary Fastenings or Fixings.

The quality and class of paper being decided upon, the next point with which the young draughtsman is concerned is the fixing or securing his sheet to the surface of the drawing board. There are two classes of methods for doing this work; one may be called the temporary, the other the fixed or permanent. The temporary may be done in two ways. First, by using small squares—say three-eighths of an inch or thereabouts on the side—of gummed paper. The drawing paper being placed as square or straight upon the surface of the board as possible by the guidance of the eye, or by the use of the T-square, is fixed in position by applying one of the squares of gummed paper with its gummed surface moistened to each corner. The square should be placed so as partly to take hold of the surface of the paper and partly of that of the board, and, in pressing it down with the thumb, it should have a slight twist or turn given to it, which will make the hold or bite of the gum all the firmer. We should advise the draughtsman to make his own gummed paper with a good strong solution of gum, made also by himself (see a note on this in "Technical Facts and Figures" in the Supplementary Section). The margins of postage stamps may be used for this purpose, but the gum now used for them is not by any means strong or adhesive, and is not in this respect at all equal to the gum employed for gumming the old or red postage stamps.

The second method of the temporary class of securing drawing paper to the drawing board is by "pins," generally known as "drawing pins." These are little discs of brass, of various diameters, usually three-eighths of an inch or "thereby"—to use a word well known to most practical men. In the centre of these small sharp-pointed steel studs or pins are inserted, being in the best made pins screwed into the disc, not merely riveted, as in the cheaper forms. We should recommend the draughtsman to purchase the best quality, which will prove the cheapest in the end.

Defects of the Method of Temporarily Securing Paper to the Drawing Board by Means of "Pins."

Of the two methods named in preceding paragraph we should say the first, or gummed-paper fastening, is much better than the second, or drawing pins. These obviously make distinctly marked holes or apertures in the surface of the drawing board at every point at which they are used. And this not only in time by constant use disfigures the surface, but, worse, the holes frequently are found to be the cause of annoyance and great loss of time to the draughtsman. For example—and this is not seldom met with—he may find, in describing a circle, that the centre of it is precisely above one of the holes in the drawing board made by a pin formerly in use. If the circle is to be described only once in pencil—or twice, if the pencilled circle has to be inked in—if the draughtsman has the "light hand" he should aim at securing, and the paper is of the best quality, or thick and tough, the probability is that his bow compass point may not pierce the paper. But if he has a "heavy hand," or if he has to describe a good number of circles from the same centre, or use the centre frequently for measurements, etc., he may find, when his bow compass point does pierce the paper, that, passing into the drawing-pin-hole in the board surface beneath, such a "wide-gaping aperture" will be made in the paper as to dispel all hope of describing circles from such a centre accurately. No doubt, in such a case the little appliance used in such cases, as when many circles are to be described from the same centre, may be employed.

THE TECHNICAL POINTS CONNECTED WITH THE EMPLOYMENT OF FORM AND COLOUR IN INDUSTRIAL DECORATION.

CHAPTER I.

Introductory.

The purpose of all decoration is to beautify the object to which it is applied. We do not here propose to enter into the discussion of the question as to what constitutes beauty in an object of art. What has been said upon this much disputed point—at least, as much of the discussion as is useful for our general purposes—will be glanced at in succeeding paragraphs in this paper, and more incidentally in other papers, as "The Ornamental Draughtsman," "The Cabinet Maker," etc. We here take it for granted that the artist who proposes to apply design to decoration has in his mind the principles of what constitutes beauty according to our best authorities; otherwise he is not prepared to carry them out into practice. Our present purpose is to give a general statement of the principles of decorative art, following this up with some remarks under separate heads, showing their special application to certain departments of art manufacture, such as pottery, wall decoration, and the like.

Decoration of Form.

And first as to the decoration of form. And here the young art student must bear in mind that we are now considering those objects which have a certain shape or configuration giving solidity—the term form in the meantime not comprising those shapes of surface which have an outline no matter how varied in configuration—that is, which have surface only. The first or primary principle we start with is that the decoration adopted—whatever be its style—shall not interfere with the true or original form of the object. Take, for example, a Greek vase. This, so far as its form is concerned, may be divided into three parts: first, the body, comprising the bulk of the vase; secondly, the neck; and thirdly, the base. Take first the base, as treated in Greek art. The decoration of this part consisted in the avoidance of all cross or angular lines, and in the imparting to them a perpendicular or vertical direction, so that the body of the vase would spring from the base as naturally as the flower from the calyx. The base or foot generally was decorated with bands of varying width; the lower part, or what may be called the plinth, having a band broader than the parts which receded.

As regards the body of the vase, where it springs from the base, or "foot" as it is technically called, the lines spring upwards, pointing towards the upper part or "neck" of the vase—embracing it, as it were—after the manner shown in the illustration of a vase given elsewhere. There is but little doubt that this principle of decoration was borrowed from nature, as in the growth of plants and flowers, in which it will be found abundantly displayed and most suggestively illustrated. Those lines are, as seen in the illustration (fig. 1), sharp-pointed or lancet-formed. And above the termination of these there is usually a band encircling the vase. This band forms the base for the decoration of the body of the vase; and as a rule—with, of course, exceptions—the height of this band from the foot is about one-fourth or thereabouts of the height of the vase. Above this line of the band the principal decoration of the body (*a*) of the vase begins. This decoration was dictated by the use to which the vase was to be applied. A very frequent style of decoration employed for the ornamentation of this part or body of the vase is what may be called the "processional," where a line of dancing fauns, satyrs, and vestal virgins encircle the vase. Such vases were in all probability designed for and used in religious processions and ceremonies.

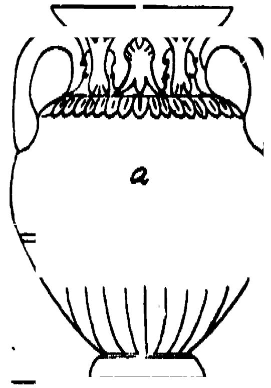


Fig. 1.

Above the procession of figures, just on the shoulder or point where the body of the vase begins to taper into the neck, bands encircle the part. Those are usually ornamented with floral decorations within or between the bands. Then encircling the neck comes a series of bands, generally with pointed forms between. At and upon the lip comes the ornament known as the echinus moulding, or egg and tongue, the outline of which is the quarter round or ovolo (see the series of papers which take up the subject of the Designing of Mouldings, and the distinction between the Grecian and Roman styles).

The Principle involved in the Foregoing Remarks as to the Decoration of Form.

The reason why we have given these explicit remarks we would wish to make very obvious to the pupil, showing him the manner in which the Greeks decorated their vases in the way described, and which succeeding generations through many ages have felt and declared to be right. The student will observe that the decoration they employed *in no wise interfered with the shape or form of the vase.* If he has any difficulty in at first conceiving how decoration could alter form, he has only to consider that, by adding to the form of a vase lumps, so to designate them, of fruit and flower projections—to which we cannot honestly attach the name of ornament—it is by no means a difficult matter to alter the form of any vase, however elegant in its true or pure form. To put the point in an absurd, yet perfectly truthful way, one might make a vase assume the shape of an unhewn rock, or some grotesque fabulous animal. Examples — too abundant, unfortunately — may be met with daily at present in the shop windows of our towns, the product of what is called "art manufacture." What claim to this title such monstrosities have, we leave the student to judge after what we have said and have yet to say. The only merit we see in such decorations—if so they may be called—is that they can be easily knocked off: a fate or result devoutly to be wished, as there would then be some chance of seeing what the original or true form was.

True Decoration does not interfere with the Nature or Utility of Form.

The above remarks must be taken as involving principles applicable to the decoration of the surfaces of all forms, although they are specifically illustrated by these forms known generally as vases. From these principles the special canon or rule to be deduced is this—namely, that no matter what the form may be, its decoration should never interfere with the purpose for which the object has been made. This may be here illustrated, and with a direct practical purpose, by a boat. This, the product of the inventive ability to design and the mechanical skill to construct which man possesses, is designed to overcome or master the physical difficulties arising from the known characteristics of water, which naturally presents obstacles to his progress of locomotion in going from place to place— in brief, to bridge over, so to say, what would be as impassable gulfs separating localities. And this bridging over of otherwise impassable spaces is done in such a way, that while we obtain facilities for progressing rapidly, we at the same time secure personal comfort in being kept from contact with the water, and comparatively absolute safety from its known dangers. Now, a boat which thus serves the practical purposes of life, and in this sense may be looked upon as a thing of utility only, possesses other attributes. Amongst these, and specially standing out in the most marked manner, is this—that it is a "thing of beauty." What a boat displays in this way, and what other things, and grandly suggestive, a .boat shows and teaches, let the remarks of Ruskin on this very subject testify. How deeply suggestive this to many minds the commonest of common things is, the reader will learn if he reads what this finest, as he is the most honest of all writers on art, says about it. If for the first time, he will no doubt to his surprise find, that there are things about so simple a thing as "only a boat," of which his philosophy had taken no previous cognisance. Now, the art student, if coming newly to the general subject of artistic treatment of objects, may think it a somewhat strange thing to talk of the decoration of a boat. But boats have from the earliest times been decorated, and decorated they often are now. And, apart altogether from the question as to the propriety or otherwise of decorating or ornamenting a boat, which, strictly speaking, is designed only to do hard work and withstand the buffets of wild wastes of water and of boisterous winds, we take its decoration as here simply, but as we think effectively, illustrating the point with the importance of which we are endeavouring to impress our readers. The decoration of a boat may be produced in two ways: first, by having ornament external to its surface; and second, by pierced apertures of various forms passing through its sides. Take first the external ornament. But a moment's consideration will suffice to convey to the student, that the first essential attribute of a boat, after the purposes of strength to contend with subtle yet ever powerful forces are secured, is that it shall glide easily, and so to say softly, through the waters, whether these be in calm or tormented by the fierce winds into a howling waste of restless waters. Now let the student conceive for a moment the effect of externally decorating a boat— on what we have called the "lumpy" principle—as illustrated in some of the forms of vases, etc., of modern art manufactures. The mere mechanical resistance offered to the boat's progress through the water, whether oar-impelled by force of sinewy arm or by the breezes of heaven, by these excrescences, or "lumps" of ornament so called, would obviously interfere with the principle of utility, which is the very *raison d'être*, or reason for the boat's existence. And thus this style of ornamenting or decorating a boat would, in the great principle we have been enforcing, be condemned. And this is altogether independent of the question of the beauty of the form, which might be either carved out of the solid wood of the boat's timbers, or formed separately and mechanically attached or secured to its sides. Those forms might or might not be beautiful; but whether beautiful or not, they would, to put the point in bluff language, as befits the subject, have no business to be there. The same principle is illustrated in the second of the two styles, by which only we have said a boat can be decorated—namely, by pierced apertures made in its sides. Here again, as before, let the student conceive the effect of decoration of this kind upon a boat. We have said that one of the attributes of a boat is that it shall do its work quickly, that it shall receive the motive impulse of wind or muscle, so that none of it be lost or squandered away.

THE IRON MAKER.

THE DETAILS OF HIS WORK AND THE PRINCIPLES OF ITS PROCESSES.

CHAPTER I.

Introductory.

It would be a comparatively easy thing to enlarge here upon the importance of what is called the "iron trade" to the country, how much it has done to extend its commerce, and to create, increase, and maintain its high influence as the wealthiest and most powerful country of the world. Other trades, as that of the cotton manufacture, may excel it in the aggregate value of its yearly output or production; but as agriculture claims, and justly, to be the oldest and most honourable of all the callings by which man makes his living, as without its produce neither he nor his neighbours could live, so in like manner may the work of the iron maker be said to take precedence of that of all other industrial branches, inasmuch as his produce is that absolutely essential to the carrying on of their trades. The cotton and other branches of textile manufactures, to say nothing of the wide and varied list of other industrial arts, all require machines to carry on their different processes, and without iron those machines could not be made. Their presence is one of the first necessities of every branch of industrial work, and the material of which they are constructed comes from our iron works.

Brief Glance at the Early History of the Iron Trade.—Its Practical Technical Lessons.

Those of our readers who have travelled much through, or are otherwise acquainted with the topographical features of our country, know those localities which are described in trade journals and in commercial circles as "The Iron Districts." Such districts as we shall briefly describe, with all their peculiar and suggestive circumstances,—presently for practical purposes to be further alluded to,—exist in different parts of the kingdom. But it is only in a few where the examples of the works we have indicated are closely and thickly set: markedly in certain parts of the midland and the northern districts of England, in Yorkshire, as in the celebrated "Cleveland" district, certain parts of Wales, and in the west—chiefly—of Scotland. And of these, two integral parts of the kingdom, the "Black Country" stretching over the dreary region between Wolverhampton and Birmingham, and the somewhat less desolate, if still dreary one, near to and partly surrounding Glasgow, afford the best types of what are called the coal and iron districts of Great Britain. The traveller accustomed to traverse the country over and through, knows of course other districts little less typical; and many parts where, from a curious concatenation of circumstances, an iron works and a coal-field works combined, rear themselves in sole and solitary bulk amidst scenery and surroundings vastly different from those of the special iron districts we have above named. But those who have no special or business interest with the "trade" carried on in the above districts, and even some of those who have, may not know that these have not always been the seats of the iron trade. Ranging, indeed, over the centuries which comprise the history of our country, it may be said that the present localities of the trade have originated within a period only comparatively recent.

Time was, however, in the history of our country, that these, now the chief places for the supply of iron, were far from being so. So far, that some of them did not exist. From the peculiar circumstances of the early times of the manufacture of iron, the iron works were located where timber—that alone being then used as fuel, in the form of charcoal—was most abundant. This circumstance gave to counties south of London that pre-eminence as seats of such a trade in the production of iron as then existed, which the counties north of it now alone possess. It was in Sussex, Surrey, and in Kent, that formerly, in generations long passed away, the chief seats of what then represented the vast source of wealth now involved in the iron trade existed. Of the works of former days in those counties, the remains in heaps of scoria, forming now chiefly green and flower-covered mounds, and much less frequently decaying or indeed decayed relics of the works, how they came there, and what purpose—if he ever thinks that they had indeed any purpose—they served, the unlettered peasant, as he slowly guides his plough through the fields by which they are so often surrounded, but little cares to know.

But the manufacture of iron—and in those early times the term was much more applicable to the trade than now, for then it was literally almost by *hand* that it was carried on, iron making occupying a large place in the concerns of the iron-master—was carried on in many districts of the kingdom, from a very early period. Those wonderful people the Romans, to whom modern civilization owes so much, no more neglected this than they overlooked other sources of power. For abundant evidence is still extant to show that they discovered the localities where iron ore existed—although from their limited resources of working at command, they chiefly, if not wholly, availed themselves of the deposits which cropped out actually at or were found at very easily reached distances beneath the soil. And it is equally beyond doubt, at all events would be so if researches were made, that by the monks of the early and middle ages the actual working of the iron trade, and probably in its highest then developments, was greatly promoted.

At the city of Gloucester, so early as the date of the Norman invasion, the manufacture of iron was carried on to what would then be called a great, but which with our experience we may call only a considerable, extent. And it ultimately reached to such a point that, as we shall hereafter see, the heaps of scoria or cinders—rich comparatively in unreduced or unextracted metal—as the result of it, came to do good service to the manufacturers of a much later date. But, as we have hinted at, Sussex was one of the chief, if not the chief, seats of the iron manufacture of the early times of this country. Worthy old Fuller, to whose quaint history of the "Worthies of England," written so early as 1662, modern historians owe so much not always acknowledged, says of this great seat of the iron trade, "great the quantity of iron made in this county,"—not only worked up there into various articles then in use, but sent to other parts of the kingdom, and (this feature of the then trade not known to many, who conceive that we always then wholly imported) exported "beyond the seas." Fuller names several "worthies" of the iron trade who did much to increase its importance and to extend its uses. Then, as now—and the fact is a curious commentary upon some views somewhat pertinaciously put forward—the making of ordnance and appliances for war formed a very marked feature of the trade, and then, as now, was the means of introducing improvements in working and new applications of its materials.

The Seats or Localities of the Iron Trade.—Some of the Conditions of and Improvements in the Manufacture Iron.—Technical Points connected with these.

Those who have occasionally passed through, if they have not tarried for a time in the iron districts—of which we take as a striking type that locality in the midland counties of England known everywhere as "the Black Country," already referred to—must have been at all times struck with features which are altogether peculiar to them. If not the first which he takes notice of, it will not be long before certain objects will loom largely in his mind as some of the most remarkable features of the locality. Those are the huge and high mounds of dark and grimy material, which but little lighten up the too frequently prevailing gloom of the locality. Those mounds—unlike those on the plains by the banks of the Euphrates—entomb no records of a past people long ago died out. They are solid masses of heavy material, in some measure like the huge blocks of which the Pyramids are raised, although, unlike them, they are thrown down at random, assuming what form the law of thrown-down material dictates. Some of the mounds stand silent and deserted, dating back from a period many generations anterior to the present. They are composed of a hard-surfaced material, almost indestructible. And, but little influenced by weather, they are not covered so kindly by the hand of Nature in the way in which she generally conceals the otherwise ghastly features of the old relics and ruins of man's work. The whitish-yellow surfaces of the blocks of slag may get black and grimy, as they generally do, with the falling soot of the smoke-infected district; but it is long, very long indeed, before they are lichen-hung or moss toned and coloured, and still longer, if ever, before on and around them the wild flowers flourish and the grass grows green. Some of the hugest and highest mounds to be seen in the busiest of these "black" districts present a twofold aspect: part is unmistakably old, others quite new, as portions are being daily added to the heap, as evidenced in the still fiercely burning or the glowing red masses which have been but recently thrown down. Those mounds are the heaps of slag, one of the "waste products" of the iron manufacture. They are a nuisance, and a costly one, if for no other reason than for the valuable ground they occupy, and the time expended in the compelled labour which they entail in heaping them up. But the truth is slowly dawning upon men's minds that, as in the works of nature God has so beneficently and benevolently ordained it that there is no such thing as waste, so is it likely, to say the least, that the same rule holds good throughout all the works of man. Far-seeing men of science, duly recognising this to be a law, have patiently worked it out in connection with several products which not so long ago were known but too well to be "waste"; and which almost universally were considered to be for ever doomed to be such. But those "waste" substances, those at one time nuisances, have under their skill been transfused into valuable products, the sources in some instances of enormous wealth. We need in proof of this cite but one instance—the utilisation of the tar refuse of the gas works—which has long yielded, under the potent power of the chemist and the skill of the manufacturer, what are really treasures. So in like manner shall we see some day these huge masses of slag utilised—in a limited sense they are being utilised now—many of them done away with, and at all events no new ones formed, for the reason that the material as it is produced will be taken, and at once utilised within or near the buildings of the iron work itself. The whole subject here incidentally, yet appropriately, alluded to is one of the greatest technical interest. And the writer of this paper may be pardoned if, from some practical knowledge of the subject, he is gratified to learn that in connection with *The Technical Journal Prize Scheme*, one of the prizes offered bears on the department of technical work known as "The Utilisation of Waste Substances."

Another feature of the dark and dismal districts of which we write—and one perhaps more striking, though in another way, than the mounds we have just referred to—are the tower-like structures which here and there rear their huge bulk amid the mingled mass of green field, mounds of slag, heaps of black coal refuse, ruined buildings, disabled furnaces, rotten woodwork, and rusty, decaying, and disused machinery which make up the mazy and murky medley of the surrounding scenery. Those tower-like structures tell their own tale, and show best at night the purposes for which they are erected. For then the flames which issue from their tops and the glowing light seen through the side openings at the top—technically the "throat" or tunnel-hole by which the "charge" is supplied to the interior—flash the sky with a lurid light, which, if not as pleasant to the sense of sight as is that of the pale moon beloved by all, goes far in another way to make up for its absence, and not infrequently to make surrounding objects for a large area as distinctly visible as when she puts forth the full glory of her strength. Only the light, though strong, is not steady; it flashes now into an almost vivid brightness, then deadens into a dulness which to the uninitiated is puzzling. How this comes about, the reader not yet learned in the "art and mystery" of the making of iron, will in due course be informed. But to one technical point connected with this feature we desire specially here to draw the attention of the reader. The observant traveller will notice that the tower-like smelting furnaces, though many are of equal or nearly equal dimensions, do not belch forth equal masses of flame. Some—and those, indeed, in many cases of the largest—yield very little flame, and that blazing forth, not from the mouth of the furnace itself, but from the orifice of a small pipe or tube by its side. And in this difference between the large mass of flame sent into the atmosphere by one furnace, and the small—in reality so—mass sent forth by another and perhaps larger one, lies the economical difference between two modes of working, in one of which a valuable body is not, and another in which it is wasted or not used. And if a substance can be and is not used, it is of course wasted. Up to a late period—very recent indeed—in the history of the iron manufacture, the huge volumes of flaming gases, and those at a heat or temperature simply intense—many hundreds of degrees—were thrown into the atmosphere, serving no useful purpose whatever. At last it dawned upon the mind of some one more practical than his neighbours that, after all, in every furnace—as in that even of a steam-engine boiler—where coal or coke was consumed, a large part of its heating power was due to the flames and heated gases passing over surfaces in connection with the work which the furnace had to do, as in the case of the flues and tubes of a boiler. And seeing this, and that a practically limitless supply of intensely heated gases and flame was sent into the atmosphere, from the tops of our iron blast furnaces or towers, the idea took possession of this observer and thinker—could not those gases and volumes of flame be used to do the work of coal or coke specially consumed in furnaces—as, say, for example, in a steam-engine boiler furnace? When we come in a succeeding chapter to describe blast furnace work in the making of iron, we shall see whether it was to a countryman or to foreigners that we owe the proposal, and ultimately its practical realisation, to "utilise the waste gases" of blast furnaces. Suffice it to say that steam-engine boilers and hot blast stoves, so to say innumerable, in connection with our iron works, are "fired" or heated without the expenditure of a single ton of crude, that is, ordinary coal or coke. And in many works, after firing all the furnaces the "iron master" has at his works by the "waste" gases, so called, thus placed at his service, he has after all volumes and volumes of these still to spare. The reader in this will have gained another technical lesson, and another exemplification of the important part yet to be played by the department of technical work to which we have specially alluded—"The Utilisation of Waste Substances."

The Abundance of Coal a Feature of the Chief Iron Districts.—Technical Points connected with this.

We have alluded to one feature of those iron districts—namely, the abundance of smoke. It is not to the tall tower-like smelting furnaces that this smoke is alone due. They do not now, under improved methods of working, belch forth much smoke; practically they may be said to produce none—none, at all events, when one thinks of the vast bulk of burning fuel they contain, which in England is almost universally coke, a smokeless fuel. It is flame, therefore, which issues from them chiefly. But smoke there is none, in the abundance which has given to one famous district, at all events, the but-too-well-deserved name of the "Black Country"; and black enough, in sky as well as in all the objects of the land itself, it truly is. No small portion of this smoke, which darkens alike the land and sky, is, in fact, produced by the furnaces of the various appliances—hereafter to be noticed—directly used in connection with the blast or iron smelting furnaces, or with the chief work of the place. So also by those connected with various trades and manufactures ministering to or supported by the iron manufacture, which cluster thickset and close around the works. But the largest, or if not the largest, the steadiest supply of smoke, is kept up by the very numerous "coal mines" or "pits" of the district. The position of these—and in some quarters they are exceedingly numerous—is indicated by another feature in the landscape of the districts of which we write. This is the tall triangular framework of timber which is crowned by two light wheels or pulleys of large diameter, which at intervals are seen revolving, and that in opposite directions. When the curious flanking motion of the two wheels is seen against the sky, or what stands in the "Black Country" for it, the initiated know that an empty basket is descending into, while at the same time a "basket" or "tub" is ascending from, the "deeps of the earth," laden to the full with ordinary coal—to which the euphuistic term is applied, with a greater degree of truth than distinguishes such designations generally, "black diamonds." And priceless diamonds they have been and daily are to us and ours—more so by far than would have been, or would be now, loads of Koh-i-noors or of "stars of the world." In no direction more valuable, or rather, we should say, invaluable, than in that which can be traced with ease in districts such as we describe. For if not the larger, certainly a large proportion of the coal thus raised in them, is taken direct to the iron works in close proximity.

The Direct Connection of or Combination between the Iron and Coal Supplies the Chief Cause of the Success and Prosperity of the British Iron Trade.

And it is to this direct combination of pits of coal with mines of iron, or rather ironstone, that we wish here specially to direct the attention of the technical reader. For in this combination will be found a remarkable exemplification of the connection which exists between, or the interpenetration, so to say, of one class of technical work with another,—a connection or combination which literally is the cause of the success of both. This feature will be seen, on perusing other papers in this Journal, to exist behind branches of trade other than the iron and the coal, with which here we have only to deal.

We are not of those who do not, will not, or who are ashamed to see in this close proximity, and in the circumstances which brought it about, and by which its rare, its essential value to our national prosperity was discovered, something more than one of the "happy circumstances," the "lucky chances," by which some love to account for all things which are marked by fortunate features,—men who apparently are content to look upon themselves and their lives as but little better than as trees floating down a stream, the sport of its waters, or as straws tossed to and fro, the plaything of the wind. On the contrary, we are of those who are not ashamed to confess with grateful gratitude that He who rules the universe has with benevolence and beneficence, wisely, for purposes of His own, created this close proximity of the coal mine and the iron mine—a proximity which enables the produce to be made in the largest abundance and on the easiest and therefore the cheapest terms. And it is to us pleasing to think that those who so confess constitute the infinitely larger proportion of our people, from which come the best men we have, the very bone and sinew of our country, rich in the rare gifts of probity, industry, ability and skill. We shall presently see how and by whom the discovery was made that coal so plentiful could be used for the smelting of iron, in place of wood or charcoal, so exceedingly scarce; and how the discovery, as exemplified in the iron trade, forming an essential element in national technical progress, turned the at one time failing tide of the iron manufacture into that full flow which has made it one of the powers most potent in making us the prosperous people we are. But it is worth while for a moment to pause here and reflect upon what is thought so little of by many—viz., how utterly dependent this prosperity has been, and is now, upon the close and intimate connection which subsists between our different trades and manufactures,—a connection not a whit the less close or valuable because some fail to see it, or seeing it refuse to learn from it the lessons of rare practical business worth which it is so well calculated to yield. Without the coal we could not have got the large and cheap supplies of the iron which the necessities of the times we have lived in demanded. Without the steam engine and the powers it gave us we could not have got the coal, and without the coal we could not have worked the engine—no more than we could have made it without the iron. All were connected in the closest way one with another, just as we know them still to be connected. And not alone with themselves, for the chain which bound them together extended itself so as to take other branches of trade or manufacture within the boundary of its links, and those again others; so that all are united by a band so common to all, that the prosperity of the one depends wholly upon that of another, and all upon each.

Brief Note on the Early Introduction of Iron as a Constructive Material, with its Technical Suggestions.

Great obscurity rests over the earliest periods of the history of the iron manufacture, of which we know but little; and of its origin, or by whom and in what country the production of a useful metal by the reduction of the ore of iron was first introduced, we know, in fact, absolutely nothing. In their anxiety to give all the sanction and the privileges of extreme antiquity to the manufacture, some writers go back to the very earliest of Scripture times as that at which iron was used for various purposes. They attribute also to the earliest periods of what is generally known as profane history, a knowledge of its manufacture as applied to a wide variety of uses.

THE MACHINE MAKER OR GENERAL MACHINIST.

SPECIAL EXAMPLES OF HIS WORK—ITS LEADING TECHNICAL PRINCIPLES AND DETAILS.

CHAPTER II.

IN our last chapter we stated that the use of metals—the new materials—was rendered imperative by the introduction of the new machines. For the class of machines which the increased and ever-increasing demand for clothing fabrics so urged the manufacturers to apply to their work to meet it with a larger supply, and which machines have been invented by able men foreseeing the coming requirements and development of "the trade," were of a totally different character, as we have above stated, from those simple appliances or machines which the machine makers had been called upon to construct. These new machines had in their essential parts complicated and even delicate movements, which could not be executed in timber, but demanded materials not only more durable, but capable of a finer adjustment than was possible where timber or wood had to be employed.

The Speed at which the New Machines were worked a Feature that demanded a Higher Class of Work from, and Tools to be used by, the Machinist.

And the use of a higher class of material was still more urgently demanded by another characteristic of the new machines—namely, the *speed* at which they were designed to work. This new feature was imperatively required; for a machine, however ingenious in its movements, and these however closely and efficiently imitating the work of hand labour, would have been of little, practically of no service, if while it did good work, it did no more of it than did the hand-workers employed before its invention. To get the full benefit of the change in the modes of manufacture, it was essential that machinery should not only increase, but increase very largely, the amount of production obtainable by hand labour only. "Speed" became, then, the feature of the working of the new machines; and this speed increased with each successive period in the experience of the new methods of manufacture by them. Nor is the attainment of this speed less aimed at now. Each new invention—and the inventions in textile machinery are yet, notwithstanding the enormous number hitherto produced, to be counted annually by hundreds—aims not only at doing better work, but doing more and more of it in a given time, and with a given outlay. And nothing would surprise early inventors more, could they return to the scene of their former labours, than to witness the enormous speed at which textile machines now work.

But this speed, as well as the employment of a higher class of materials, demanded a higher class of mechanical work—for accuracy of adjustment was absolutely required. Machine makers were not long, therefore, in seeing that all the demands made upon their skill could only be met by the establishment of a totally different system of workshop practice. And the first thing which this system required was machine tools. These held precisely the same relation to the handicraft work, then universal, by which machinery was made, as the new textile machines held with reference to the hand labour of the cotton workers which they were designed to, and actually in time did, supersede. Once this new department of machine-tool designing and making was entered upon, it gave rise not only to a class of machines used for various trade purposes, though specially and at first almost exclusively confined to textile machine work—but to a special branch of trade which is now second to none, either for the variety of its work, or for examples of the highest ability in mechanical design and the greatest skill in construction. The roll of the names of those who have made machine making what it is, is so wide, and comprehends so many distinguished names, that we cannot find space for even the briefest and baldest list. Opportunity may in the course of our papers be given us of incidentally, if not fully and in a systematic way, recording the names and taking a brief glance at the work done by at least the leading men who in the early days of "the trade," and those which more nearly approach our own times, gave by their mechanical genius, and by a perseverance and diligence which overcame all obstacles, that impress of practical value to the work of machine making which has made it one of the most striking of the many developments of man's skill and ability with which we are everywhere surrounded.

Early History of Machine Making of Great and Suggestive Interest to the Practical Reader.

A carefully elaborated and more or less exhaustive history of the work of "The Machinist," from the earliest times when it began to be a power up till the present day, would be not merely intensely interesting as a record of one of the most important chapters in the history of the civilization of the human race, and specially valuable as illustrative of those peculiar characteristics of the Anglo-Saxon race; but it would possess a direct and great value to the young machinist, as abounding in practical suggestions and lessons calculated to be of the greatest service to him in his technical education and his daily work. This exhaustive review of the past circumstances of the work of the machinist is obviously beyond the range and limits of the present series of papers; as it would take those of a portly volume or two to do even but fair justice to its many features. Prevented, then, by the circumstances of our publication from taking up this field and treating it exhaustively, we cannot however pass by some of its departments—and this in the direct interests of the technical reader. For while those interests demand at our hand illustrations and descriptions of the leading machines of the machinist, and of the machine tools by the aid of which he makes them, in the perfection of movements we every day see in them; another in many respects higher and in some sense the highest interest demands that we should point out a few, if not all of the leading characteristics of his work, and those principles which alone enable him to give to it its widest development and its highest value. To do this with such degree of completeness as our space will admit of, necessitates a glance at some of the features of the trade which, although in one sense historical, are nevertheless the vehicles, so to say, of a vast deal that is practical—while a fuller and a wider glance at other points will enable us to give such counsel to the young machinist as may be of essential service to him, not only in the study of the principles, but in the practical details of his daily work. Having followed us through this essentially useful part of our series of papers, the technical reader will then be ready to go with us while we pass in review the leading machine tools and mechanical appliances with which "The General Machinist" does his work.

Definition of the Term "General Machinist" in relation to our Series of Papers.

The trade name here given, and which is also the leading point in the title to our papers, may for their purposes be defined as that which concerns itself with the making of every class of machinery and all varieties of mechanical appliances which are required by the different and numerous manufactures and trades and the varied branches of commercial work carried on throughout the kingdom. This definition is no doubt wide, for it may embrace the work of a specialist, such as a mechanic who devotes himself to locomotive making, or one who concerns himself only with marine steam engines or with hydraulic machines — for all these use the same mechanical aids in construction. Still it is, and may be for the purposes we have in view, limited in the way we have named. And this may be said to be the popular view, as the names given in the title to our paper are understood generally as being negative at least in their import, so that when one talks of a machine maker or general machinist, it is at least known that he is not a specialist such as a locomotive or marine engine maker, etc., etc., etc.

In the pursuit of his calling the machine maker calls in certain mechanical aids to help him to work up his materials into the form of the mechanical appliance or machine he is called upon to make. These mechanical aids range themselves into two great classes—hand tools and machine tools. These are capable of doing every class of that work to which by common consent the term mechanical is applied. Of these two classes the last named is the most important,—if in no other way, at least as displaying the highest class of mechanical characteristics. Although in saying this it by no means derogates from the position occupied by hand tools, which will always and of necessity occupy a position which, so far as we can see, will not be taken up in another way—and this notwithstanding all that has been done in substituting machine—that is, power-driven machine—labour for manual or handicraft work.

Some Considerations connected with Tools and Machine Tools by which they are Made, and their almost Complete Absence in the Workshops of the Early Machinists.

Taking machinery considered as a whole, as embracing all the wide variety known as textile, fictile, motive powers, and the like, the youthful technical reader is apt to overlook the importance of those mechanical appliances and those very machine tools above alluded to, by which alone all machinery is constructed. A little consideration, however, will show him that no great advance could be made in the construction of machinery in general till the means existed in some form or another by which the mechanic could make his mere animal strength and dexterity available in giving form and working capacity to the products of his mechanical design. The records of mechanical history afford, indeed, a most interesting and, in many of its aspects, a really practically suggestive field of retrospective inquiry, in the examples which they give of the difficulties which beset inventors of machines in connection with the point we are now adverting to. We have, indeed, been greatly struck with the almost pathetic interest thrown around the records of what they had to encounter in getting their designs put into a working shape. And this not so much on account of the difficulties attendant upon the materials which they had at command, as from the, in some cases, almost wholly insuperable difficulties they had in getting these materials worked into the forms demanded by the nature and mechanical character of their inventions. In working up these forms and parts, handicraft skill was, even in comparatively recent times, almost wholly unaided by tools, and while those were of the simplest, and in "make" of the rudest, the help obtainable from what are now known as machine tools was not within the reach of the early machinists, for the best of all reasons—namely, that machine tools had at the period we are alluding to no existence. The only two our earlier machinists had was the foot-lathe and the boring brace, and those two so rude and rough, alike in form and in construction, that all that can be said of them is that they contained but little more than the elements of the modern turning and boring machines, of which almost every mechanic's shop, however small and insignificant, has now excellent examples, capable of turning out a great variety of mechanical work. The working mechanic of the present day gives, we fear, but little thought to the truth that if he were not provided with the wide range of tools and machine tools which is met with in every well-appointed workshop, he could not possibly turn out the machinery and the engineering work of various kinds, of which he is proud, and justly proud, as being what it really is—the finest and highest class work of the kind which the world produces. And it would do those good who are somewhat disposed to grumble at what they call their difficulties in doing work, if they could but know what the early inventors of machinery had to encounter in getting their machines made, and what also the machinists or handicraftsmen had themselves to meet and often found wholly to baffle them in their attempts to carry out the wishes of those who employed them. Unfortunately, the records of the early difficulties which surrounded alike the inventors of machines and the machinists who had to make them, are exceedingly few in number and very meagre in details. And this is, for us, who have entered into the rich legacies of work done and difficulties overcome which they have left us, a matter to be greatly regretted; for, as we have said, such records are interesting chiefly because they are practically suggestive. For it is in every way worthy to be remembered, that the lessons derived from failures are frequently not of less, but of much greater, value than those to be obtained from successes in mechanical work. We shall have occasion to illustrate this in more than one instance, when we come to consider certain departments of the present series of papers.

What, however, we wish here to impress the young technical reader with is this: That before the fine examples of machinery to be met with in every branch of industrial work, and in the various forms of prime movers—such as the factory steam engine, the railway locomotive, and the marine engine in their varied forms—were possible achievements, the early machinists had not only to devise or design machine tools, but to make them (and those of necessity had to work with precision and accuracy) before they could give to the parts of the machines they made, or helped the machinist to make, those characteristics of precise accuracy which have made our machines the marvellous examples of mechanical construction we know and see them everywhere around us, to be. And as forming not merely a good mental exercise, but as bringing up some singularly curious and suggestive practical facts in the way of mechanical work, we would recommend the young mechanic to consider what the problem really was which the machinists of early times had to solve, and what must have been the difficulties in the way of its solution. This problem, on which the work of the future actually depended, may be stated crudely thus: to make tools and machine tools of precision, when the only tools available to make them were so far from being precise themselves, that they were not only rough in make but rude in design. In following this up, and in attempting mentally to work it out, we venture to believe that the young mechanic will have some curious considerations suggested to him, which will help him to estimate, at some part at least of its high value, the indebtedness of modern machinists to their early predecessors.

Practical Points connected with the Establishment of Machine Making as a Branch of Technical Industry.

In following up the purposes of the present series of papers, we have, as practically introductory to the details we have yet to give of mechanical work and the parts of which this is composed, to place before the reader sundry points connected with the history of mechanical progress. And those follow up and specially illustrate what we have said above as to the importance of the work done by the earlier machinists in introducing into daily use the tools and machine tools by which alone the fine examples of modern machinery everywhere now met with could be made. The opinion is held pretty generally, even by many in the mechanical world whose information ought to be more precise and accurate than it is, that modern mechanism, no matter in what direction it does its work, owes its existence mainly to the labours of scientific men. In other words, that the practice of the mechanic is not only based upon theory, but that all the details of his labour in the workshop have their origin in, or have been suggested by, the theorist in his closet and at his desk. That all machinery works under the operation of, and must be designed in accordance with, the natural laws which cannot be set aside, and which rule all the phenomena of work of all kinds and varieties, is what of course no one disputes. Neither will it be denied that a machinist may construct a machine which throughout its movements is an illustration of and is dependent upon certain natural laws, and yet that the mechanic may be quite unable to explain, not only what those laws are, but how the machine takes, so to say, advantage of and makes them subservient to its purposes. Nay, the mechanic may have thus done work, and indeed the best work of its kind, by the aid of the machine he himself has not only made but invented, and yet be ignorant of and be surprised to be told of the fact, that it depends for its existence upon a natural law, or upon laws.

THE ORNAMENTAL DRAUGHTSMAN.

HIS STUDY AND THE DETAILS OF ITS PRACTICE, CHIEFLY IN RELATION TO TECHNICAL WORK IN MANUFACTURING DESIGN.

CHAPTER III.

THE student will, we hope, from what was said in the preceding chapter, see the importance of drawing straight lines, as the examples which follow from figs. 7 to 17 are illustrations of the application of this class of lines to ornamental purposes. Fig. 7, the zigzag, is the "Egyptian" mode of representing water, and this figure is used at a more acute angle in decorating the columns and capitals of their temples, and later it was used for the same purpose by the Greeks. All these applications will be pointed out in their proper places.

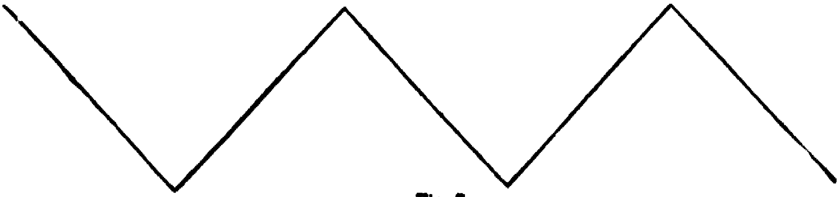


Fig. 7.

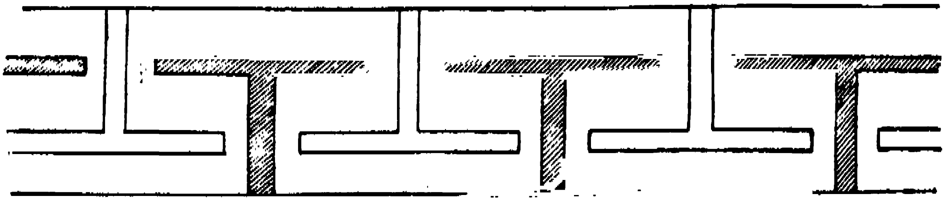


Fig. 8.

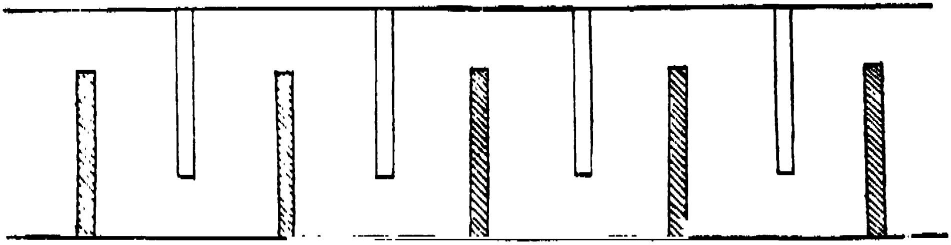


Fig. 9.

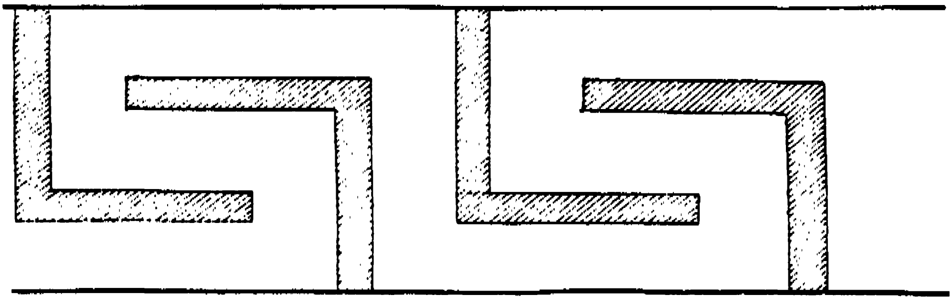


Fig. 10.

Examples of Straight-lined Figures · Elements of Ornamentation or Artistic Decoration.

Fig. 8 is a simple fret or labyrinth; this ornament is used in most antique styles by the Egyptians and the Greeks; the Japanese and Chinese also use it. The Greeks used it in a very elaborate way, as will be seen in the accompanying figures, 10, 11, 12 and 13. The fret in fig. 9 is wholly made up of straight lines vertically disposed. The fret in fig. 13 is more elaborate, and introduces a new feature—namely, the panel—as at *a a a*. The pupil will observe that in some of the ornamental arrangements the lines are vertical and horizontal, whilst in others they are oblique. Should the student extend his studies into the history of ornamental art, he will find there a mine of interesting information; and using the term *wit* in the sense in which Burns uses it, we can assure him

> "There's wit there, ye'll get there,
> You'll find nae ither where."

Bearing this fact in mind, and for example that the history and habits of the Egyptians are written in their arts, one can see in their picture-writing a history more clearly shown than words could explain.

In figs. 10, 11 and 12 the pupil will observe that in the frets there illustrated the lines are at right angles, as the line *a b* to *b e*, or *d c* to *c f*. But in figs. 14, 15 and 16 the lines are oblique, and in fig. 17 the lines cross. These frets, in ancient or classical art, are as a rule met with as a painted decoration; it is only exceptionally that they are used in cut or sculptured forms. The frets are used as an ornament in all antique styles, but those we have given are from the Greek. The Chinese use the frets as an ornament very extensively in their bamboo or cane work.

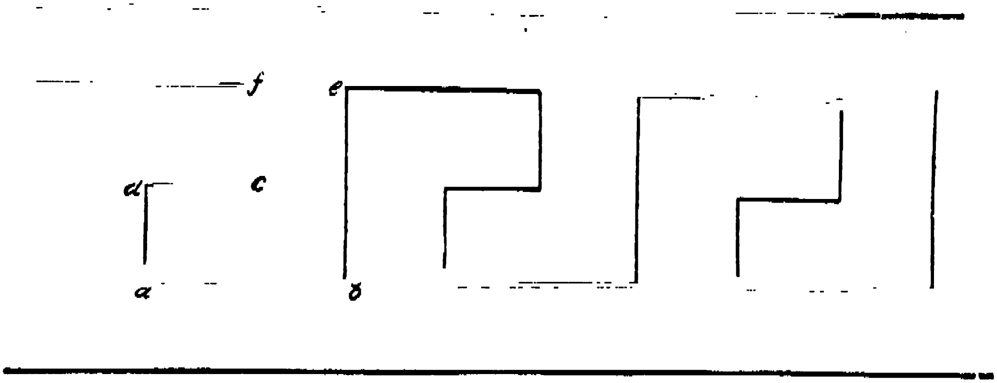


Fig. 11.

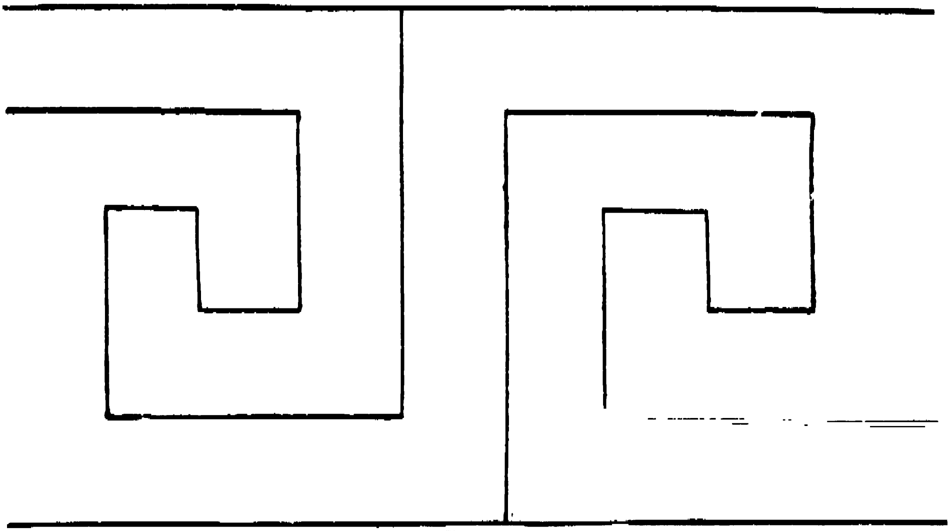


Fig. 12.

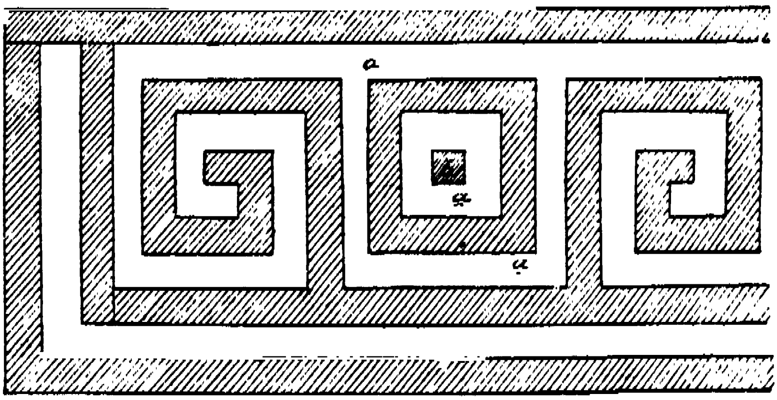


Fig. 13.

Importance of Straight-line Drawing to the Ornamental Draughtsman.

And now we have gone with the pupil through these most important subjects. The early ones may be said to be the essential, as they form the basis of the practice of ornamental drawing; but in another sense the succeeding drawings are essential also, for they constitute the basis of ornamental art, distinguished from what may be, and is correctly enough, termed pictorial art. And this work we have done, we trust, with a fair degree of honest and earnest endeavour to do it satisfactorily—that is, usefully to the pupil. He has had the purpose of those drawings laid before him, and their characteristics explained. With some little interest in his success, we have put before him the inducements for studying their peculiarities, and have not concealed from him the fact that those difficulties are considerable. For it is certain that the men who have the power to draw a straight line with absolute accuracy are, like the proverbial angels' visits, "few and far between." Many artists are woefully deficient in this direction. Line-drawing is not attended to with one-half of the assiduity that it should be. A student here and there begins to play with shade and colour, and sneers at stories about Prout's straight line or Giotto's circle. Nothing will then satisfy him but wonderful effects in *chiaroscuro*, or glaring "Venices" with impossible skies, Naples yellow and purple-red buildings, and golden boats on emerald-green waters, etc., etc. The youngster may, perhaps, by some good piece of fortune, at last find out his foolishness and error, and the only possibility of artistic salvation for him is a return to such work as this—namely, the figures now before him.

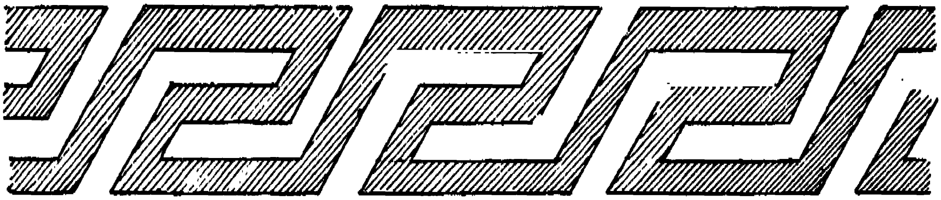


Fig. 14.

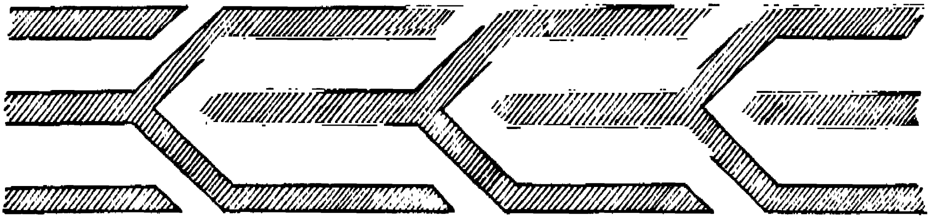


Fig. 15

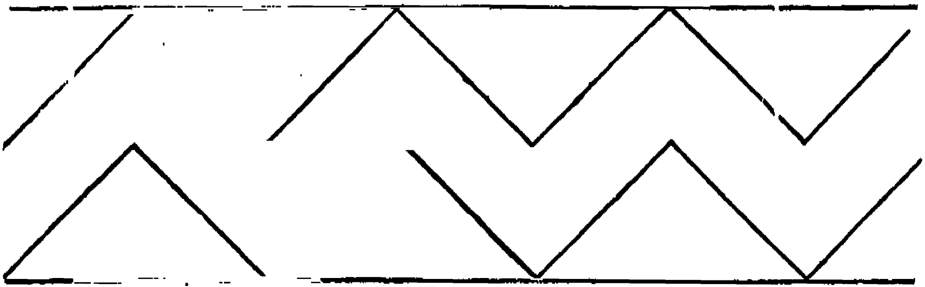


Fig. 16.

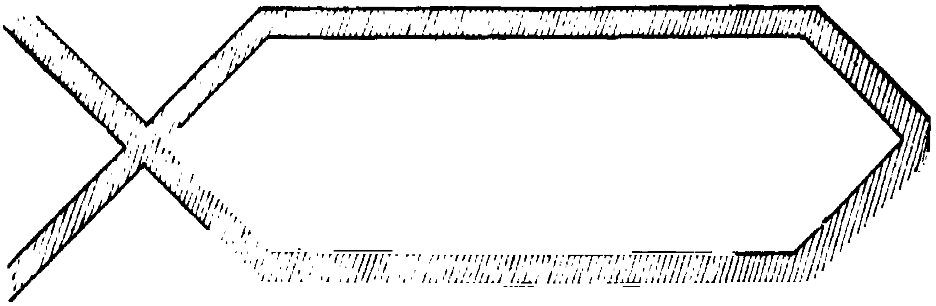


Fig. 17.

THE CABINET MAKER.

THE TECHNICAL DETAILS, AND THE PRINCIPLES AFFECTING THE DESIGN OF HIS WORK.

CHAPTER I.

Introductory—Names of Technical Trades do not always give an Index to the Nature of the Work or the Materials employed.

IN glancing at a list of the names by which the various branches of our industrial callings are distinguished, one peculiarity is noticeable. The names do not always indicate the materials which are employed by the various workers, so as to give a direct clue to what their work actually is. Some, on the contrary, are distinguished by names which at once tell us what their work is, and sometimes the specific material employed or chiefly employed in it. Of the first class we may cite as instances the trades of the joiner and the carpenter. The first of these names conveys not even the faintest conception of what the trade actually concerns itself with. The term "join" is by all, of course, understood; but it might be applied to the joining together of any materials, or of more materials, however diverse in character, than one. There is nothing in the name to convey definitely an idea of what the work of the joiner really is—this being simply the working up of timber into the various forms and fittings required in the interior (chiefly) of our domestic and public buildings. And it is probably from the circumstance that on the accuracy of the joints by which the pieces are held together the perfection of the work has been estimated, that the term joinery has been selected to designate this special class of work, as if to indicate that unless the joints were well made the work would be worthless. But it is obvious that the term or name might be given *per se*—that is, by itself, simply—to a worker in iron, or a machinist, both of which trades have a great deal to do with joinery; in fact, their work actually is the formation of structures by the joining of one part to another till the whole is completed. And in this sense, strictly taken, almost any of the constructive or mechanical trades might be called joinery with as much accuracy as in its usual designation, if at the same time, to give a definite meaning, the material the trade used was added, such as a joiner of metal, joiner of wood, of stone, etc.

Of course, by long usage, and as it were a species of traditional descent, every one knows what is meant when we speak or write of the trade of a joiner, just as every one knows what the special work of a carpenter is; although, so far as the names or words themselves are concerned, they give no clue whatever as to the precise character of the work. Thus, a person who had no traditional knowledge to fall back upon, who had not been accustomed to hear on all sides what such callings really were, and what the character of their work was, would never gather from the mere trade name of "joiner" that his work was such as we have above described it to be, any more than he could from the name "carpenter" the fact that his occupation was the formation of parts of timber structures out of large pieces of wood, just as that of the joiner was the using of wood in small or comparatively small pieces (see the papers entitled "The Joiner" and "The Carpenter). The same indefiniteness is met with in the word masonry, and it is only—as is very usual—when the special trade is designated, as that of the stone mason, that we know that stone is the material with which he deals, and the shaping, cutting, and "joining" of separate pieces or blocks of which he forms his various structures the special work.

The Names or Designations of Some Trades give at once an Index to the Nature of the Work done and the Materials employed.

Other trades, however, there are about which there can be no doubt as to what the special character of their work is. Thus the names of Painter, Plasterer, Cotton Spinner, Cloth Weaver, Machine Maker or Machinist, Gas Maker, indicate at once what the work of the trades is, and give clues more or less direct and specific as to the materials they use. If the reader will think over the point here named, he will perceive that there is more in it than appears at first sight, and that nomenclature is or should not be a mere dead thing, but one of vitality, exercising an influence, when rightly applied, for good. If it be true, as some philologists—and we confess with great truth—maintain, that the *morale* of a people is largely indicated by the terms, the phrases and the proverbs of its daily life, it is difficult to escape from the conclusion that there is something indicative of the practical tendencies of a people in the names by which they designate their various occupations. If precise definition of scientific terms, or of the materials employed in the arts be—as it is universally acknowledged to be — of great importance, it can scarcely be denied that some importance at least is attached, or should be attached, to the mere nomenclature of our technical callings. It is at least a satisfactory—and to the mind appears to be a fitting thing—when the name we employ conveys as directly as possible what in reality is its chief, if it be not its only characteristic.

Technical Lessons derived from the Names of Trades—Cabinet Making.

The last-named point to some may seem to be a matter of indifference, but to those who are not content to skim over the surface of a subject, it will be found to be the reverse of this, and to carry with it something practical in its application to the work and the purposes of daily life. Precision of expression is surely more solidly satisfactory than vagueness, and matters are not mended, but are worse, when not only is precision sacrificed, but a wrong impression is conveyed as to what the work actually is; leading to the belief that it is only one thing which is meant in place of a variety of things. Very much in this way does the term "Cabinet Making" operate. The meaning of the term cabinet is pretty generally understood when reference is made to the fittings of our houses, but the term cabinet maker does not apply solely to a workman who makes cabinets and cabinets only. True, he does make these articles of interior fittings, but it is well understood by all that he makes something more. In point of fact, the cabinet maker, as the term is now universally understood, is one who makes those interior fittings for our buildings which go under the name of *furniture.* And although other trades have and require their furnishings or furniture, as the actual phrase is—for example, the "door furniture" of the joiner, as locks, hinges, escutcheons and finger plates—the term is generally accepted as indicating only the interior fittings or furnishing of our domestic buildings. Properly speaking, these interior fittings are of two classes of work—namely, of the joiner and of the cabinet maker—but the work of the joiner is confined to the fittings, such as architraves to doors and windows, skirting boards, doors and windows which are fixed in position, and form, so to say, integral parts of the structure or building; whereas the interior fittings of the cabinet maker are all movable or capable of being changed in position as desired.

The Work of the Cabinet Maker comprehensive in its Character.

The work of the cabinet maker being then, as we see and all generally know, of a more comprehensive character than that concerned solely in the making of cabinets—embracing all the parts which constitute what we call domestic furniture, as well as the classes of ecclesiastical furniture, etc., etc.—a more precise and definite name for the trade would have been "furniture maker." No doubt this has in reality been employed, and is still employed by many. But, arising no doubt, as we suspect, from a notion that there is something—no matter what—derogatory or undignified in this the plainer and more definite term, as it is apt to be confounded with the more humble occupation of a furniture dealer, this name furniture maker is generally disused, and what appears to be the finer phrase cabinet maker is employed.

Suggestive Character of the Early History of Furniture Making.

It is something more than interesting—it is often suggestive of something practical—to trace the history of an art or the progress of an industrial calling. And if we do this in the case of furniture making we find some explanation as to how the term cabinet making came to be applied to the art, Furniture strictly so called, as indicating the interior fittings of our rooms, is divisible into two great classes—first, those pieces which are required to be moved more or less frequently, as tables, chairs, and couches or sofas; and second, those which, once placed in the desired position, are kept there. Although furniture fittings are in the strict sense of the term movable, as contrasted with the fittings of the joiner, which are fixed, this mobility is thus seen to be relative only—one part of furniture being fixed, as a rule, the other part capable of being shifted from one position to another. In the middle ages, that period in which the furniture of houses occupied a distinguished position, and engaged the services of the first artists and the most skilful workmen, its distinguishing feature lay in the *cabinets,* the great chests or coffers, or the presses. Upon these, distinguished as they were from their prominent size, all the ability of the artist, all the skill of the workman, was lavished. And as this class of furniture required of necessity the greatest care in its construction, it would in time come to be looked upon as what may be called the test work of the artificer. So that if he could construct—all the better if he could also design—a fine cabinet, he would as a consequence be able to make the lesser pieces of the furniture of apartments; and as the greater includes the less, he would come to be termed a cabinet maker—just as if the term cabinet making included all the lesser work of interior finishing. Furniture in the widest acceptation of the term, while it is essential as ministering to the comfort and to the conveniences of daily life, may be made also to conduce largely to its intellectual pleasures. While useful it may be beautiful. And when once a more healthy, because a more correct idea of what the beautiful truly is, and what the high office which it fulfils, becomes a part of our intellectual and we may say moral education, it is beyond a doubt that the furniture of our houses will be looked upon in a greatly different light from what now generally, we may say universally, it is. We shall then have our furniture beautiful as well as convenient.

Furniture: its Characteristics; and some Points in relation thereto.—Beauty and Utility, both frequently sacrificed for the Sake of Cheap Work, and sometimes not at all considered.

To those, however, who have got the notion that our furniture is beautiful because it is pretentious, or to some who take even a lower view of the matter, and decide that it must be beautiful and good because it is costly, what is said at the end of the preceding paragraph must appear a strange, if not a startling conclusion to arrive at. Judged by an artistic or æsthetic standard by no means high, this is the only conclusion one can come to who honestly looks at furniture as it now pretty generally is, and frankly states his opinion of it. For when judged by the higher standards of artistic beauty, too much of our modern furniture is seen to occupy a position but little removed from the utterly barbarous in art. Those who may be disposed to doubt, indeed flatly to deny this, have but to examine the records at once documentary or written respecting more artistic furniture, or better still, the specimens which fortunately have been handed down to us as ocular evidence of what furniture was in times long gone by. It is not that money is now grudged by those who possess it; it is in other ways, and even in point of fact in this department, expended as lavishly as it is expended with little or no true artistic satisfaction. Nor is it that those who possess means are unwilling to have really beautiful surroundings in their houses. The truth would seem rather to lie in this direction: that, however desirous they may be to get beautiful furniture, it cannot always be had, for it is not now often made. To this, according to our highest authorities, the exceptions are lamentably few; and even where exceptions exist, they at their best fall far below the magnificent work of bygone times. At the same time it is only right to say that those who have abundance of money have not always an equal supply of taste or a knowledge of what constitutes the truly beautiful. And if those had this, it is obvious that they would possess a great power in bringing about a higher and more satisfactory state of things in regard to furniture. For of this they may rest assured: that if they refused to have, no matter what it was which tradesmen offered them in the way of furniture, and would pay only for what they knew to be of a higher class of beauty, the tradesmen would very soon make an effort to meet the wants of their customers. They are but too glad to find a market for their goods; and if these be false in taste, meretricious in design, the fault lies very much with the public, whose taste—if the term be here permissible—is false, so that they will have what they believe to be beautiful, but which all rules of art too easily prove to be the reverse, or anything but beautiful.

But, as we have said, it is not so much a matter of money. For it may be accepted as a truth, certainly in connection with furniture, that the same cost of labour and material will give in one case an article truly beautiful, in another one positively the reverse. And this, be it observed, does not apply to simple objects of comparatively small cost,—it applies with equal force to the most lavishly ornamented and the most expensively constructed articles of furniture. With some, indeed, it seems to be a settled thing that if you only put labour and material upon a piece of furniture it must be beautiful. Hence the monstrosities we see sometimes, in which costly construction, expensive carving, and "no end of ornament," gilding, and the like, strive, so to say, to be the most obtrusive—giving as a result objects which a man of cultivated taste would not have at any price, to which on no terms would he give, as the phrase is, "house room."

Lack of Ability to Design, rather than that of Skill to Construct, frequently shown in the Work of the Cabinet Maker.

If this be true—and it will, we take it, be somewhat difficult to refute—it would appear that what is wanted is not so much skill to construct as ability to design. Of the skill to construct in the best possible way there is no lack amongst our workmen, provided they be paid for it, and paid well—for a dissatisfied workman is rarely a good one; provided also,—for there are two sides to this bargain,—that being well paid, the workman who can work is so honest, and takes such high pride in his calling—which is the only guarantee for good work—that he will give the very best he is capable of. But if good work can be had easily enough, and can certainly be increased to meet any demand (for merely mechanical skill is by no means so rare as some seem to think), the same cannot be said of good design. The shortest way to excellence would of course be to gain the combination so common in the too much despised middle ages, when the workman was almost always an artist. Failing this, the next best thing to aim at is to get good designers. Good workmen to carry out those designs would, as we have said, be got with comparative ease, for of a given number of artisans by far the largest number will be found who are capable of being educated or trained to be clever and skilful constructors—with whom nothing could be done worth the result of the labour bestowed in the way of making them designers.

Improvement in the Work of the Cabinet Maker.

While, however, making such strictures as we have deemed it right to make on the position which, as a rule, furniture as an art manufacture occupies at the present time, and while asserting what we have, with but little fear of having our assertions proved to be wrong, if facts as they exist around us, and which can be gathered from the houses of the great majority of the people, be appealed to as the only source of facts, we at the same time are far from denying that improvement is now being made. We are, on the contrary, only too glad to admit that it is so, and to point with pleasure to the fact that it is something more than merely at the first point of initiation. The improvement made within the last few years is beyond doubt something more than merely tentative or initiatory. It has in some quarters made large advances, and a very much higher and healthier tone exists, and amongst a very much wider class, than existed even so short a period as ten, or say a dozen years ago. To quote the words of one who himself has done as much as any one in this particular branch of manufacture to raise it to that position in which it is worthy of having the prefix of "art" attached to it, "That advance has certainly been made; a reaction from ugliness to beauty has touched at least some part of the people who live among civilization, and in what we technically call the decorative arts This new *renaissance* has been helped in this country by many agencies, not least among which has been the steady endeavour on the part of the Department of Science and Art to spread artistic education among the public in general." And the result of this, so far as the branch of art manufacture of furniture is concerned, is —again to quote the words of the same authority—such "that any one can now find in shops all over the country goods at commonplace prices, which both are intended to be and are beautiful, and more or less marked by artistic individuality; that, in short, any one who chooses can make the interior of his house comely and pleasant without an unreasonable expenditure of time and trouble." But we should be taking but a low estimate of the duty we owe to our readers, and paying but poor allegiance to the cause of the development of artistic taste amongst all classes of society, if, while fully admitting the truth of what the authority we have quoted says as to the *choice* open to all to have new furniture of higher claims to beauty than was possible to them but a few years ago, we failed to point out that the misfortune of the thing is that the great majority of the purchasing public do *not choose* to "make the interior of their houses comely and pleasant." And this not because they are absolutely unwilling to do so, or are indifferent either to comeliness or pleasantness, but simply from the fact that their artistic taste is so poorly developed. Or, to put it more truly so far as a vast proportion of the public is concerned, it has no existence, so that they do not actually know how comeliness and pleasantness, in so far as those are dependent upon and created by the beautiful, are constituted, and upon what principles they depend.

Artistic Taste requires Development before Beauty in Furniture can be understood or appreciated.

The above may seem to some of our readers a very harsh decision to arrive at; but we appeal with all confidence, in proof that it is but too true, not merely to the opinions of those who are in every way qualified to give it, but what is better, as it will be more convincing, to the facts and circumstances of everyday life by which we are surrounded. No doubt those who possess these "surroundings" may well say, as many no doubt would if appealed to, that they are perfectly well satisfied with them, that in their estimation they are comely and pleasant—in short, in their eyes beautiful. This, however, is but, as it were, Cæsar appealing to Cæsar, and he who makes the law is likely to think well of it. But the point is not whether what they deem to be beautiful, as being comely and pleasant, constitutes the beautiful in reality, but whether their conceptions are based upon the principles which, according to authority beyond all dispute, guide, dictate, and create the truly beautiful. And tested thus, there is but one conclusion open to us—namely, that the opinion we have above stated is simply the true one, and that the great majority of the purchasing public do *not* choose to avail themselves of such sources of obtaining furniture "comely" and "pleasant," and in so far therefore "beautiful," now open to them, and this because their artistic taste is so little developed that they have even at the best but a faint conception of what really does constitute the difference between that which is and which is not beautiful.

Wide Lack of a Taste for Decorative Art amongst the General Public.

But while this is true, it is true also, and unfortunately for art, that another and a very large, perhaps still larger section of the purchasing public, do not choose the comely and the pleasant, simply because they do not think that any choice is at all necessary. They simply buy what their neighbours buy, or buy with as much exercise of thought of their own in the one case as in the other, what the maker or dealer chooses to provide for them. And it is scarcely necessary to say that but too many makers and dealers purposely, if thoughtlessly, do provide what is neither comely nor pleasant. We corroborate this assertion, made with all due consideration, by the opinion of the high authority we have already quoted; and we do so inasmuch as, whatever some of our readers may think, the majority will join with us in believing that the whole question is one so fraught with practical importance of the highest kind that its consideration must not, should not in the true interests of the reader, be passed lightly over. For in truth the art education of a people is no light matter, and lies very much nearer to the heart of our social and moral progress than some wot of. What, then, says our authority on the point we have above given expression to? While gladly admitting the great improvement made in the art manufacture of furniture during the last twenty-five years, he goes on to say, "I am afraid I must admit that the general public are *not touched at all*" (we purposely italicise these pregnant words) "by any interest for decorative art; a *few* of the upper and middle classes *only* have as much as heard that there is such a thing as decorative, which should be popular, art."

THE STONE MASON AS A TECHNICAL WORKER.

THE PRINCIPLES AND PRACTICE OF, AND THE MATERIALS HE EMPLOYS IN, HIS WORK.

CHAPTER II.

Ashlar-built Walling—Dimensions and Proportion of Stones.

IN this all the stones are blocks of considerable dimensions; the least thickness or depth—reckoned vertically as the stone lies in bed or in the course—being twelve inches. The stones for the best class of work should be carefully proportioned, the length, depth, and breadth having what is called a harmonious relation to each other, and the breadth, as *a b*, fig. 11, or length from front face *e a* to back face *b d*, never less than the depth or thickness of the block, as *a c*. If the length, as *a e* or *b d*, fig. 11, be from twice to thrice the depth or thickness of the block, as *e s* or *a c*, or two and a half times, and the width or breadth, as *e d* or *a b*, twice or double the depth or thickness, *e s* or *a c*, the block may be looked upon as well proportioned, or having its surfaces in harmonious relation to each other.

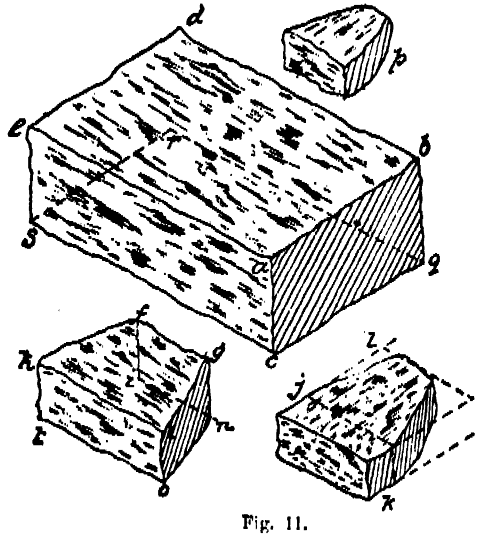


Fig. 11.

False Ashlar—Defective Forms of Stones.

It is very defective ashlar work, and always gives unsound or unstable results proportionate to the extent to which the bad system is carried out, to have the block cut so that the length of the back face, as *f g*, fig. 11, is less than that of the front face, as *h i*. This work is but a shade removed from that utterly bad system of cutting an ashlar block when there is a certain depth of the block cut square in all directions, giving only in reality a narrow rectangle or parallelogram of the proper dimensions, as shown by the dotted line *j k*, in place of the full and proper rectangle of upper face shown by the dotted lines *j, k, l, m*. This is false ashlar, and is in reality a block of rough or random rubble with merely a false face, as at *j k*; and is well entitled or classed as veneered or "sham" ashlar. Blocks so cut will give still worse work in the wall in which they are used if in place of having the depth at back, as *g n*, the same as the depth at front, *i o*, it is less, as at *p*. With stones cut as shown, *h i o n g*, and rounded at bottom, as at *p*, no properly *bedded* and *bonded* work can be obtained; and, as we shall see presently, upon good bedding and bonding all sound or stable ashlar work depends.

Technical Terms or Names of Parts of Ashlar Blocks or Stones.

The faces of an ashlar block have different technical names. Thus the term "bed" is applied to both the upper and lower surfaces, supposing the block to lie in the same position as when in its proper place in the wall of which it is to form a part. But the lower surface—that is, on which the block rests on the stone or course immediately below it—as the surface shown by the partly full and partly dotted lines *s, c, g, r*, in fig. 11, is called the "bottom bed"; the upper surface, as *a b d e*, being the "top bed," on which the next block of course immediately above rests. The vertical surface which is exposed in the wall, or forms the front or visible surface, as *a e s c*, is called the "face" of the block; the part shown in full and dotted lines, as *f g n i*, the "back."

Polished or Rubbed Ashlar Blocks or Stones.

All the faces of true ashlar blocks are tooled and dressed to form a cubical block, with all its faces at right angles. And to further ensure good bedding and a good joint in mortar, the faces are all "rubbed" so as to give perfectly smooth surfaces. This rubbing is done generally by means of a piece of the same stone, the rubbing down being aided by the use of water; although dry stone rubbing may be resorted to, especially to finish off the surface when dry after wet rubbing. In large blocks two stones may be placed face to face upon each other, and the upper block dragged to and fro over the surface of the lower one, water being used to facilitate the rubbing. Ashlar blocks so finished are termed "polished," sometimes "rubbed" ashlar work.

Tooled or Dressed Ashlar Blocks or Stones—Different Methods in Use: Straight-lined or Plain Tooling · Rusticated Work.

In place of having the "faces" or exposed surfaces of ashlar blocks smooth by being polished or rubbed, they are frequently "tooled" or "dressed" in one of a variety of ways. Those are very numerous, and go by a great many technical names; many of which, although indicating the same class of work, are known by names prevalent only in one district or part of the country, and not used in other districts or parts. The surface may be tooled with a sharp-pointed chisel so as to present a series of lines extending all over it. These may run horizontally along the length of the block, as in fig. 12, or vertically across the breadth, as at *a a*, fig. 13, or diagonally, as at *b b* and *b*, same figure.

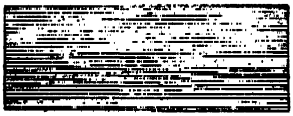


Fig. 12.

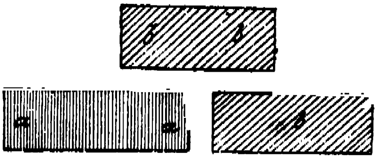


Fig. 13.

In place of having the rowing or lining to extend over the whole surface of the "face," a margin is sometimes left all round the lined part, as at *a a*, fig. 14, in front view of face, and in sectional view at foot of sketch. The surface of this margin may itself be lined, but in a different way; or, as is generally the case, left smooth. But it is generally rowed or lined where the surface is purposely left rough, as shown in fig. 15, which illustrates in front or face view what is called "rusticated work." In this the greater part of the face is tooled so as to present a series of projections or knobs of varied outline and size, the general effect desired to be attained being regulated by the size of the block and the position it occupies in wall or structure. There are different modifications of rusticated or rough-faced wall, known as "rough-faced," "frosted," and "sparrow-pecked" work, etc., etc.

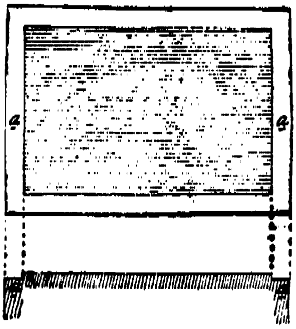


Fig. 14.

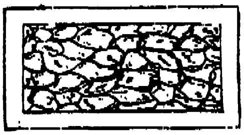


Fig. 15.

Other Methods of Finishing the Faces of Ashlar Blocks or Stones.

In place of having the face of the stone flat, it is often finished with a rising part sloping off, as at A in fig. 16. All the sides of the projecting part slope inwards, of course; they may meet at a point, as in A and B, B being the end view, A the side view of block, and as at the right-hand side of the diagram C, to the right of the dotted centre line, this being a plan or top view of the face. Or they may meet in a point only at the sides, the end sloping part stopping short at some distance from the centre line shown dotted. In this figure the diagram D is a side sectional view, showing at the left-hand side of the centre line how the end sloping surface stops short of the centre point of the block face. The appearance thus presented of the surface of a wall built with blocks tooled and dressed in this fashion, is very much like that of a series of roof-sloping surfaces in miniature. The sloping surfaces do not start from the extreme edges of the face of block, but a margin is left all round, as shown in C, the surface of which may be called the true face of the block, the sloping part being as it were only an addition or projection, supposed by those who use it to be ornamental.

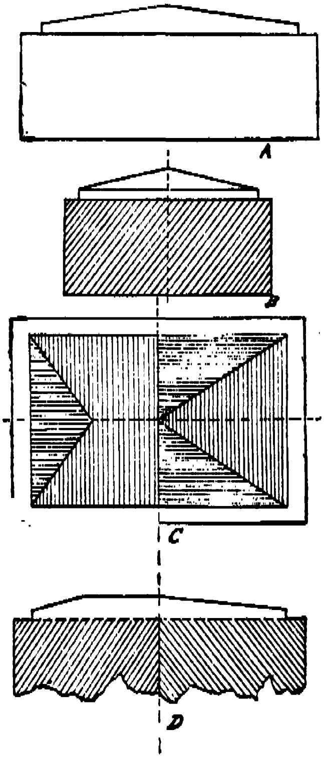


Fig. 16.

Forms of External Joints in Ashlar Stone Walling.

In ordinary "polished," "rubbed," or "tool rowed or lined" ashlar work, the joints formed by the superimposing of one course above another, show only straight lines, as at top and bottom of stone *a a* in fig. 13; the fineness, or rather closeness, of the joints depending upon the style of the workmanship of the mason in laying the blocks. In the best work the joints show very close, the layer of mortar between the beds being very thin. Mortar of the best quality is, of course, in this class of work only used. In some cases, while the actual joints, that is the bedding surfaces, are in good work very close, the apparent joint, as viewed in looking at the general surface of the wall, is very open or wide. On looking closely at an example of this the reader will perceive that in some examples of open joint work the sides of each joint slope inwards at such an angle that they meet at a point in line. This line is placed centrally between the upper and lower line of the joint; and the effect is produced by cutting the edges of the "face" of block all round at an angle, as shown in diagram E, fig. 17; so that when two stones so treated are placed "on bed" they form in section two angles, as shown in the sketch at the right hand of diagram E; that to the left being a front view. When four stones, as *a, b, c, d,* in diagram G, are placed together, the meeting of their angular edges gives the appearance as in sketch. Open joints, where the appearance they give looks like a series of grooves or channels, as in front view in sketch F, fig. 17, with rectangular sides and flat bottom, are produced by cutting a rebate or marginal part all round, as shown in the sectional sketch in H. Figs. 18 and 19 illustrate courses of parts of walls in polished or rubbed ashlar work, with open joints above described; fig. 18 illustrating the form of joint obtained by cutting the edges of face of block in the manner illustrated at sketches E and G in fig. 17; fig. 19 the form of the marginal cutting as in H.

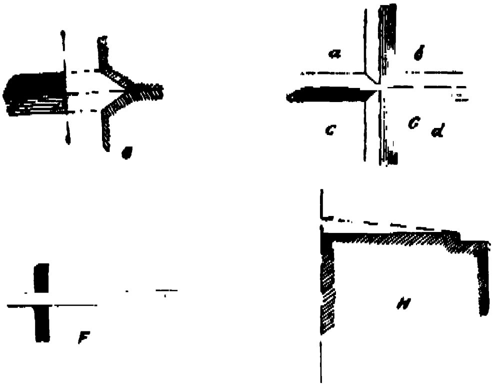


Fig. 17.

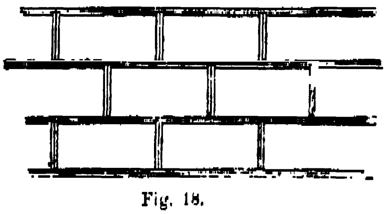


Fig. 18.

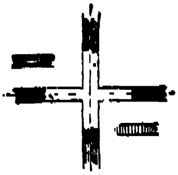


Fig. 19.

"Bond" in, or "Bonding" of Stones in Walls; Its General Principles and Importance.

The practical work of masonry consists not merely in the selecting and cutting, dressing or tooling the individual blocks or stones, so as to give to them certain solid forms or shapes; but in the way in which these stones are placed together and superimposed one upon another. We have seen that on the nature of the bedding faces of stones, used in the building, say of a wall, much of the stability of the structure will depend. If the bedding surface or "top bed" (as *a b d e,* fig. 11) of the block be perfectly flat, much of the advantage obtained from this flat surface will obviously depend upon the nature of the "bottom bed" (*s r g c,* same fig.) of the stone which is to form part of the course immediately above. If this bottom bed be very uneven or rough, and especially if its thickness, as *n g,* varies, so that the "back" face, as *f g n i,* is of less depth than the depth *i o* of the face *h t o i,* the upper stone will tend to "rock" or sway to and fro upon the face of the other or lower stone. The vacant space formed between the two stones thus placed may be filled or jammed up with smaller stones, or with thick mortar; but it is evident that this style of treatment—often, however, adopted in practice—is only an endeavour to get rid of the evils which careless workmanship has brought into existence. It is clear that the most perfect joint between two stones, one resting upon the other, will be that in which the surfaces of both stones are so even and regular that the greater part of the two surfaces will touch each other. This cannot be the case, of course, in "rough rubble," or even in "coursed rubble" stones. Still in the latter a certain good bed is often obtained, and consequent joint, by the interlocking, so to say, of the two surfaces, the projecting parts or knobs of one going into the depressed parts or hollows of the other. And in the case of "rough or random rubble" work this interlocking or dovetailing, so to say, of one stone with another, can be secured to a considerable extent by careful selection and adjustment of the stones.

Admirable examples in abundance are met with of "dry stone" wall work in Yorkshire and districts of England where rubble or rough stones can be easily and plentifully had, or in Scotland, where work of this kind is carried out extensively. They afford excellent examples of the skill of the masons, who are indeed bred to, and only practise, this species of masonry.

Theoretical and Practical Conditions of a Wall—Courses in Walling—Joints in Walls, formed by the Courses Vertical and Horizontal.

But the stability or strength of a wall or structure depends not only upon the form which each stone considered by itself possesses, or has by special tooling and working given to it; it depends also, as we have said, upon the manner in which the number of stones making up the structure are disposed in its bulk or mass. Each coursed rubble or ashlar wall is theoretically considered as a solid mass throughout, being defined as a solid prism or parallelopipedon, standing on a rectangular base of much greater length than breadth. But practically this solid is made up of a series of layers parallel to the base and to each other, each layer being as a rule of equal thickness or depth throughout the wall. The technical name given to each of these horizontal layers is a "course"; and as the courses are independent of each other, one resting upon the surface of the one immediately below—being separated only from each other by the mortar used to cement them together—a series of joints are formed along the lines of heights of stones. But there are vertical joints also. That is, two are formed by the end of one stone "butting" up against, or being placed in contact with the one or nearest end of the stone placed next to it on the right; the other end with the stone to the left. A third joint is formed by the back face of the stone if it butts up against the face of another in the same course. In fig. 11 the horizontal joints are on the lines *e a*, *s c*—the vertical on the lines *e s*, *a c*—the back vertical joint being on line *b g*. This back joint is not present, of course, in cases where a stone is of length sufficient to form the full thickness of the wall, as in the case of what is called a "through" stone, presently to be described and illustrated. In this case there is no back vertical joint, as the two faces or ends of the "through" stone are exposed, one to the front or outer, the other to the back or inner face of wall.

Function or Uses of Joints in the Courses of a Wall.

Those "joints" formed by the contact of faces of adjacent stones afford surfaces by which the different stones are obviously kept together or from separating by being connected or glued together, so to say, by a mortar or other binding and cementing material. The very friction, indeed, between the two rough surfaces—rough enough even in the case of polished or rubbed ashlar faces—would tend to keep stones superimposed upon and placed in contact with each other in the courses or layers. And this friction between the stones, or the "grip" which one stone takes of the one above or below it, forms an element in the construction of a "dry-stone wall," referred to in the last paragraph; but one which must not be lost sight of in estimating the strength of a wall of this kind. An element of higher value than some might be disposed to assign to it; who conclude that it is from the interlocking of the stones between the stones as referred to, that a dry stone wall alone derives its strength and stability. But this merely adventitious or artificial binding of the stones together, in the case of walls in which mortar was used, would be unsafe to trust to, in endeavouring to secure a stable wall capable of resisting strains or sustaining pressures calculated to force the stones asunder or to separate them. The full advantage of the cementing or binding power of mortar or of special cements (see a succeeding chapter on "Limes, Mortars and Cements") is not here undervalued by saying the above. There is great binding or cementing power exercised by mortar when it is good in quality, and judiciously applied—for in this, as in all other work, there is a bad and a good way of employing mortar, which we shall in due place notice. Mortar made by the ancient builders, and even by those at the very early part of the present or late in the preceding century, was in very truth mortar. Being of the best quality, it hardened like stone in process of time, and set indeed so fast that it formed in itself a kind of artificial stone in many cases much harder and more durable than the original stones it bound together. So hard and firm that it was, and is to this day, no uncommon thing for extensive areas of walls to fall or be forced over, and to fall to the ground in a solid mass, not in the slightest degree shattered or broken up. No modern-built wall, certainly very few walls, could stand a test of this kind; mortar as now used by but too many builders—falsely so called, for they do not build in the true sense of the term—being a lime cement or true mortar but in name only, that is, a composition in which sand plays an all too important part. And this sand, it is worthy in this connection of being here noted, is of itself sometimes not of the quality to give a good mortar. For as there is lime and *lime*, so there is sand and *sand*; on both of which points we shall have something hereafter to say.

THE FARMER AS A TECHNICAL WORKMAN.

HIS TOOLS, IMPLEMENTS, MACHINES AND MATERIALS.—THE PRINCIPLES OF HIS WORK IN ITS VARIOUS DEPARTMENTS.

CHAPTER I.

Introductory.—Farming as a Useful Work to be done.

To those who may take a somewhat exalted, or as they may term it, a dignified view of farming, regarding it as a science rather than as an art—taking it, therefore, more as a thing to be studied than concerned with work which is to be done—the title we have chosen for the subject to be considered in the chapters which are to follow will, we fear, be looked upon as something derogatory to what they may probably call it, namely, a profession. But those who know what farming practically is will perceive how thoroughly appropriate the title is; for if any man has essentially work technical work—to be done, it is the farmer. And if the definition of the term "technical" given by the writer of the paper in the present work entitled "The Workman as a Technical Student—How to Study and What to Study," an advance proof of which is now before us, be correct, then the farmer is essentially a technical workman. And we believe this definition to be correct, and thoroughly go along with the reasoning of the writer upon which he bases it, and which, in due course, our readers will have presented them for perusal. Those of our readers who may not be acquainted with farming as it practically is, if they favour us by a perusal of what we purpose under our title to give, may rise from it with some conception of how closely the farmer who successfully practises it deserves the title we have given him. Nor will the reader have the less clearly imparted to him that if, as the writer above referred to justly says, all honest work is dignified, that of the farmer has higher claims than the majority of workers in any branch of industrial work which ministers to the necessities of the people—we might safely say the highest claim—in this regard.

Farming a Dignified Calling.

For there is no work which man does that brings him in such close contact with Nature and her works as that of the tillage of the ground, or the care of the flocks and herds which are supported by its produce. The only work akin to it is that of the gardener; and for the matter of that the terms may be interchangeable, for the gardener may be considered as a farmer, but only of tinier crops, with this added value, that some departments of his produce minister, by their beauty and fragrance, to the higher delights of man,—just as, on the other hand, the farmer may be said to be a gardener. And this last way of putting the case carries with it considerations of a more thoroughly practical character than some of our readers may at present understand or appreciate. This we shall have occasion to illustrate in a succeeding chapter. Meanwhile we repeat that the work of the farmer is the most dignified of all our industrial callings, bringing him as it does into contact with all the higher manifestations of Nature's operations. The more variety, to say nothing of the individual characteristics of each one of the many plants he grows or the animals he rears, affords examples of natural phenomena the interest attached to which never dies, as its characteristics are as varied as the influences under which they display themselves. To the thinking farmer the field opened up to his observation is alive, so to say, with a countless host of objects, not one of which, in its characteristics and their development, but what is suggestive of a train of thought, of a line of investigation, or of an experiment which will call forth his highest powers. For, whether he chooses to learn them or not, his work is calculated to teach him lessons of higher worth and nobler import; which, while they will healthily incite him to be pre-eminently a good worker, will adorn his life with all those graces of goodness which will make it nobly useful to others and yield the highest satisfaction to himself. Nor do we lose sight of the hope that we shall be able to show to such of our readers who may not at present possess, not a full, but even a fair knowledge of what farming is that although we designate him in our title as a technical workman, we do not lose sight of, but rather indeed include, as of necessity, the fact that his work is dignified in a sense other than that to which we have just now alluded; so that he may be said to be, in the truest sense of the term, a scientific worker.

Farming as an Art and a Science.

We here, of course, assume that the farmer as a technical worker is a trained workman. Trained in the highest or most complete sense—that is, who not only possesses the manipulative or other skill necessary to *do* the work demanded of him, but *knows* what the work is, what are the principles upon which it is based. It is thus that—to use the popular expression—farming is at once an art and a science, a thing of practice and of knowledge. Both of these requisites to success in farming, as indeed in any class of work, are, however, involved in the term "technical"- that is, when the definition of the term is accepted such as is given by the writer of the paper "The Workman as a Technical Student." Taking, then, work to comprehend or embrace alike the capability to *do* or perform its various requirements, and the capacity to *know*, that is, to learn and apply the principles upon which it is based, and without which work cannot, in the proper, the highest sense of the term, be said to be done at all,—it will be the object of what is under our title to be given, to convey, as it ought to demand the best endeavours of the writer to secure, a thoroughly practical exposition of what farming is in this double sense, of a thing to be known and to be done practically. The reader, whom we suppose as yet not to know much of the subject as a whole, may reasonably and readily enough conjecture, what is, after all, but a very commonplace conception of what farming is designed to do, that the details of its practice are numerous, if not complicated. But although he may so conclude, it is, we think, pretty certain that he will be in no small degree surprised to learn that before a man can be in the true sense of the term an accomplished, or to use the more homely if better understood phrase, "first-class farmer," he must know, and know thoroughly, a very wide range of scientific subjects of study and practice. So wide, indeed, and so varied in their nature and in their modes of practical application, that if we gave now a mere bald enumeration of them, the reader might well conceive that a lifetime would be required to master these alone, leaving no time for their practical application. Certainly he would conclude, and with justice, that any farmer who knew those varied branches of science even moderately well possessed every claim to be considered, and indeed truly would be, a very learned man. And this conclusion would be eminently just; and in the lives of more than one farmer it has been remarkably exemplified. It has been the lot of the present writer to number amongst the friends made during a long life many farmers; and of these, again, not a few were fully entitled to be called learned men in the sense of the term we have used above. There was scarcely one of what may be called the practical or applied branches of science but what they showed they possessed a knowledge of far beyond and above what may be called table talk or surface acquaintance with it. And this position is what the reader concerned in or intending to be concerned with the practical working of farming should aim at securing. He may not be able to secure it in all its valuable efficiency; but the higher things are those for which he should strive; for if he does not get all of them, he will get some, and what he does procure to himself will be worth getting. We trust that in this endeavour he will find some help from what we are now about to present him with in these pages.

Aim or Object of the Present Series of Papers—Relation of the Subject to Technical Work.

In what we have to present in this direction, it is obvious that the space given to us, and into which we have to compress so much which must have attention paid to it, will in itself prevent us from going deeply into all the scientific details. But we shall, we trust, be able to give the general results of the scientific research of those who have devoted themselves to the important subjects concerned with the practice of farming in such a way that they may be applied with comparative ease to the details of that practice. Whether this knowledge of scientific results will be applied by the reader to his practice, rests with himself, not with us. It is one thing to present a starving man with food, another thing to persuade him to take it—for even starving men have been known to quibble and deny that what was given them was food at all—and quite another thing to ensure that even when taken it will be assimilated by him, and so assimilated that it will not merely save life, but will nourish and promote it for after work. In this matter, then, the reader "must minister to himself." There are some phrases in daily use amongst us which have certain meanings attached to them, and have become so fixed and stereotyped, as it were, in the minds of men, that no matter how desirable it may be that there should be another and a wider and truer meaning given to them, it seems hopeless to expect that this higher one will ever be given to them. Amongst those phrases is that of "working man." Now, although that term is applied to a class of the community which is a very wide one, both as regards the diversity in the callings of its members as well as regards the vast aggregate of their numbers, still those who look below the mere surface of things know well how narrow its meaning is, and how narrowing also, and more unfortunately, is its educational and social influence. This work, of which the present chapter forms a part, is, on the other hand, an example of the much wider and higher meaning which the term carries with it when rightly defined. This is essentially a book connected with work, and is therefore pre-eminently one adapted to the wants and wishes of the men who do it. But the merest glance at the list of subjects which its pages discuss will suffice to show how wide and varied the lines of this work are, and how wide by consequence must be the class, or rather, as we should say, how numerous the classes, by which that work is done. The pages of the work, therefore, clearly do not address themselves, and were not—as far as an outside view of it enables one to judge—designed by the conductors of it to address themselves, to one class only, however numerous that class might be. It aims at meeting the wants of that great class of technical workers who minister in a wide variety of ways to the wealth and influence of the community as a whole, and through these to the individual benefit, social, moral, and industrial, of all. The working men, then, whom this book addresses, belong to no special class, and the phrase "working man" has in it, therefore, a much wider and higher signification than that given to it in popular acceptation. Its pages purpose to help, so far as their medium possibly can help, all classes who wish to do their work well, whatever kind of technical work that may be. It will be useful alike to the man who has been college bred, taught in technical schools or classes, and it is to be hoped even in a more telling way, a more efficient degree, than those who from the circumstances of their lives have been precluded from all the advantages of early and special education, and are now eager to make up for their loss of time by doing what they can for themselves in the way of acquiring knowledge, by the plan known popularly as self-education.

Relation of the Object or Aim of the Papers to the Ordinary Working or Farm Labourer.

And applying these remarks to the special subject of the present paper—in view of which, indeed, they have been penned—such information as it may give in the course of its succeeding chapters will be valuable to those who are either about to engage in farming, or are studying with an aim at some future time to do so, who may belong to the class able to afford not only the education necessary to make them good farmers, but to be able to take and cultivate farms. But some readers whose "lines may not be cast in such pleasant places," who may in fact be of that class popularly known to be but "working men," may have a difficulty to see how such information as we may give is likely to or can be useful to them practically. Now, it is not given to every one to be at the top of the tree, still it is one's duty to climb as high as it is possible for him to do; and certainly one will never begin even to try to climb who sits or lolls lazily at the root. We need say no more on this point, which is indeed so clear and self-evident that nothing more than what has been said is required to show its importance. And the very fact of any one of the class here indicated—namely, working men possessed of no means to push themselves but their determination to do so—reading this gives evidence that he is at least desirous to get on in life, so far as study will help him to get on. And there can be no doubt of this: that a thorough knowledge of one's work will be the best possible help to him to get on. For the man who is known to *know* his work well, is in the best and highest sense of the term a "marked man." He is of a class of which the members are too few, unfortunately, not to be highly valued when they appear. And when promotion is going on—as it always is going on in business, say what grumblers will to the contrary—the promotion does not go to the lazy, the indifferent, and the ignorant, but to the man who, whatever his work has been, has determined that he will know it thoroughly and work at it honestly, who, whatever his rank may be, determines that he will, if possible, be the first of his rank. A man of this class is sure to get on, for the best of all reasons,—that the value of its members is known, and as we have said, they are too scarce not to have a high value. Now, what we have to give will, we venture to say, be at least one of the helps by which he will be assisted in the work of getting on—which may, in other words, be called the work of self-improvement.

Nor is it true that a veritable working man, in the popular as well as the true sense of the term, is not likely ever to have a farm of his own. We do not say that every one will, or that every one can, however good he be; but we do say that there are far greater chances of a farm servant, or a working man in some other class of work who has a love of the country and of country work, getting a farm of his own, than many are disposed to admit. As we write, one of the farming papers we read weekly has just come to hand, and our eye has singularly enough lighted on a paper entitled "Farm Labourers," which takes up this very subject, and points out in how many instances farmers now holding good positions, and some of them of eminence as practical farmers, were at one time, and that not so very long ago, labourers, and but labourers on the farms of others. One case named by the writer, a very well known and able farmer himself, is worthy of special notice here: that of a farmer who now farms, and farms well, no fewer than five hundred acres, and who for years had to keep himself and family on ten shillings a week, beginning life with wages so low that at seventeen years of age he could and did earn only three shillings a week. Surely there is encouragement here; and such cases, we know, are not special in the sense of being isolated, for we heartily endorse the statement of the editor of the farming paper we have alluded to when he says—and few are better able to give a sound opinion—"We believe there are but few estates which could not point out some of their best tenants who have once been labouring men." Let one fact be remembered: that young men now are very much better off, not only as regards the wages they receive, but in respect of having opportunities of self-improvement, which leads to that of personal position, than those were who began life so many years ago. Of the truth of this, the writer may be pardoned if he refers, as a striking evidence, to the work in the pages of which he is now privileged to address his readers.

This not only makes the work of progress easier, but, rightly looked at, all the more a duty to oneself as well as to society that it be honestly performed. And the doing of this duty necessitates not merely the cultivation of all the higher intellectual and moral powers, but those which give the skill—the handicraft power—necessary to make knowledge of practical avail. No matter on which side we look, in what direction we push inquiries, we find that nearly every help, legislative, social, educational, is put within the reach of every young man desirous to rise in the world.

THE DOMESTIC HOUSE OR HOME PLANNER OR DESIGNER.

THE WORK OF THE YOUNG ARCHITECT OR BUILDER IN THE DESIGNING OF HOUSES FOR TOWN AND COUNTRY.

CHAPTER II.

Some Practical Examples of Mal-Arrangement of House Apartments (Continued).

IN our preceding chapter we gave in the last paragraph some remarks under this head. Referring the reader to what was there stated, we proceed to analyse the examples named. If the position of this cellar-kitchen could not be very seriously objected to—although graver objections on the score of health can be held against all sunk or semi-sunk rooms used as living rooms, that is, apartments in which one branch of the family remains habitually—let us briefly examine in how far this position affected the convenience in doing the essential work of the house. The kitchen, placed as we have seen in a story below the dining-room or ground floor of the house, was reached from this upper floor by a flight of steps placed at the back and *outside* of the house, leading into the yard or back garden. This flight of steps could not be objected to either on the ground of being narrow or very steep, for there being ample room, both requisites in a good stair, width of step and easy or long inclination or angle, were so far fortunately secured. The original idea was that when the domestic had to go from the kitchen to the dining-room, for example, above—say with the dinner apparatus and materials—she had to issue from her cellar-room to the back yard, ascend the steps, open the door at the head of the flight leading to the passage or lobby of the ground floor, and traverse nearly the whole of its length before she would reach the door of the dining-room. It would look as if we had but a poor conception of the intelligence of the reader if we deemed it necessary here to point out to him the inconvenience, loss of time, etc., arising from the carrying on of the daily, ever-recurring work of the house, at all times and in all weathers, with such a singular arrangement or "plan" of this part of the house.

Some glimpse of the singularity of the arrangement—to characterise it in the mildest of terms—seemed to have crossed the mind of the builder, or to have been suggested to him by some one who had a clearer notion of what was really due to the domestics of the future house on the score of comfort or of health; probably by some proposing tenant, for it was at a later stage determined to give the girl or girls a more direct mode of access from the kitchen to the upper rooms than had been originally proposed, and this the only possible way out of the roundabout method. That this, if more direct, could not be a very easy access, may well be conceived when it is considered that the walls of the cellar or semi-cellar kitchen having been already built, the space for the flight of stairs had to be taken off or deducted from the working space of the kitchen.

Deficiency of Floor or Working Surface in Kitchen, etc.

And in the special case we are now analysing, the working space at the best was so straitened that it could only be called the minimum of what ought to have been its floor surface or dimensions. And it is worthy of remark here, that this deficiency of working floor space in kitchen, etc., is a characteristic even of high-class houses, upon which so much having been expended to secure a fine style in, one would suppose that some expenditure would have been given to obtain comfort in the working parts of the house. The flight of stairs was, therefore, of the narrowest, and in order to gain the height required for the ascent not a few had to be given to it of those awkward and always inconvenient and too frequently dangerous angularly-shaped steps known as "winders." (See further on in this paper, and in the series of papers under the heads of "The Joiner" and "The Mason," for a full description and illustrations of the details of Stairs.) The result was the giving of a flight of stairs of that class which has been graphically termed "break-neck stairs." So very marked an example of this class, that when the house came to be inhabited, the servants had such an objection to the use of the flight—fearing, if not a catastrophe of broken limbs, at least that of plates and dishes—that they rarely used it, direct, in such fashion as it could only give, as the access was. They preferred the safer, and in that sense easier access of the roundabout system, with all its loss of time and discomforts in cold or bad weather. But these, not so much grumbled at at first, became so grievous by the never-ending repetition to which we have already referred as a most important element in all such or similar cases, that servant after servant gave up the "place" rather than be so tortured.

The Fireplace or Cooking Range in relation to the Window of the Kitchen.

The final adjustment of the difficulty, if not altogether satisfactory, was at least so far so that it gave peace to the household. And it was this. The all-too-straitened sitting-room before alluded to as forming one of the rooms—so called in this case on the principle of *lucus a non lucendo*, because it was not a room in the useful sense of being roomy—on the ground floor, adjacent to the drawing and dining-rooms, was made into a kitchen. But being so straitened, "ample room and verge enough," or at least as ample as could be given, was obtained by knocking out a part of the back wall, extending the floor space outwards, and giving the window at the back of the newly-formed "set-off" or projecting part.

But thus arranged it was but a very inconvenient kitchen at the best, for it was merely a long narrow strip of an apartment, with the light thrown so far away from the fireplace that cooking had to be done in a very obscure light. And this, at the best of times, was made more obscure by the fact that the cook had to "stand in her own light," as she had of necessity to turn her back to the window. As a convenient kitchen it certainly could not be classed, yet in convenience notwithstanding it was far in advance of the original arrangement, for it saved time and fatigue.

Further Illustrations of Mistakes in House Planning—The Lessons they yield.

We could cite many other cases, which, though not so glaringly defective as the one we have given, are yet bad enough. And as we would take the illustration from actual practice, we may predicate that the mistakes exist in other houses, or may yet exist—for what has been done once may be done again, however unlikely the doing of it at all may appear to be. It is difficult indeed to say how absurd may be the mistakes which some house planners or designers may perpetrate. For example, a plan *has* been known to be sent out for a house in which no provision was made for a staircase by which the bedroom floor could be reached from the ground floor. And had the building been proceeded with far enough, there would have been but two alternative methods left of getting over the difficulty—either building an outside staircase, or taking part of the space from one of the entertaining rooms on the ground floor, and a like space from the room immediately above, to give a landing on the bedroom floor. Fortunately one who knew what a plan ought to be discovered the grotesque mistake—for in one sense it was so—of the original planner, if indeed such a designation was applicable to him.

Such a glaring absurdity as this now named, some of our readers will scarcely give credence to, it being so unlikely that any one *could* perpetrate it in practice. But those who have had large experience in house planning, and who have, as a consequence, seen what is wide practice, in which the work of others is shown, know too well that mistakes, if not quite so gross or grotesque as this one, are made, and often made, in house planning. And, unfortunately for those who have had to live in the houses so planned, the mistakes perpetrated in them had not been discovered before the building was completed.

Omission of Storing Conveniences in House Plans.

One would suppose, for example, that no one sitting down to plan a house could be absolutely ignorant of the fact that in every well regulated household, articles in daily use, such as dishes, cooking utensils, and the like, after being used, are cleaned and put away ready for employment on other, and as a rule quickly recurring, occasions. Nor is it easy to suppose that the planner could be altogether unaware of this fact: That, as people have to eat to live, and live to eat, and as provisions for the same have to be bought and kept in readiness for use, as a consequence some kind of place or apartment is required in which they can be so kept. We repeat that it is difficult to conceive that the planner of a house could be ignorant of all this. For living in a house or home, as he must have done, where the comforts of life were to be had, surely he could not but perceive that such things were required for comfort, and therefore demanded certain conveniences. And yet he may just as well have had no observation at all, and been absolutely ignorant of all the work of daily domestic life, for practically his plan showed no provision for it. We are not in this merely supposing a case. For not once merely, but frequently in the course of professional examinations of houses, have we come across examples where there was but the very minimum of "conveniences" for carrying on the daily work, and some where they did not exist at all. No doubt the latter case we have only met with in cottages, or houses of a poor class. But even in such cases it was an unpardonable sin for the planner of those houses to arrange them so that not a single convenience was provided for putting away things not always but very frequently used, or for storing up such small supplies of provisions as scantily filled purses can alone command. Unpardonable, inasmuch as the planner must have known, or ought to have known, that poor people have their little comforts to be attended to just as much as those in superior ranks—all the more, in fact, that those comforts are but few. Still more unpardonable if, while knowing this, the planner refused to minister to the comforts of the "huts where poor men lie," on the score that it was quite a matter of indifference whether they were ministered to or not. The other sin would, or might be, that of simple ignorance or neglect; this one would be *a sin against humanity.*

Storing Conveniences, as Cupboards, Pantries, Larders, and the like, Essential even in the Poorer Classes of Houses.

And while on this point, let us parenthetically remark, although the point is one deserving of fuller treatment, that we may talk as we like—and very frequently "big talk" is indulged in—of what we choose to call the untidy, careless home habits of the poorer classes, but we forget that we not only encourage these, but positively plan and build their houses in such a way that it is an absolute impossibility for them to be anything else than untidy or careless in their home habits.

THE SANITARY ARCHITECT.

THE PRINCIPLES AND PRACTICE OF HIS WORK, IN HEALTHY HOUSE ARRANGEMENT AND CONSTRUCTION.—TECHNICAL POINTS OF SEWERAGE AND DRAINAGE, VENTILATION, ETC.

CHAPTER I.

Introductory.

TIME was, in the history of our country, when the term or title which forms the leading part of the heading to the series of papers now begun would have been to the great bulk of the community simply meaningless. For although the term "sanitary" had a place in our dictionaries, it had none in the common language of the people—none, at least, as conveying even the remotest conception that it carried with it ideas connected with the doing of practical work which closely concerned, not merely their healthy, but their moral and social well-being. At this period in our history now referred to, all classes were content to live under circumstances of house construction and its immediate surroundings, without ever troubling themselves as to whether the conditions which those involved were in their results beneficial to their health or the reverse. Now and then, in consequence of some striking and painful outbreak of disease, or some startling series of deaths, which in intensity amounted to a calamity, the attention of a few thoughtful men was directed to the subject, and some conception, more or less decided, was obtained that there might be a connection between the catastrophe and the houses and their surroundings in which it had happened; and some notices, in a way more or less public, might be taken of the point in some isolated journal of the day, or possibly a less vanishing place might be given to it in the pages of a book, or through the medium of a paper read before some learned society. But even this slight movement of the waters of ignorance or absolute popular indifference to the subject of the health of the people as affected by their homes and the conditions by which these were surrounded, is only a matter, so to say, of yesterday—but a day or two ago in the history of the nation. The present century had certainly reached its first quarter before even scientific men generally began to think that there might be some connection between the construction of houses, the conditions by which these were surrounded, and the sickness so often ending in startlingly numerous and striking instances of death which marked out some, and even wide districts, as, so to say, the hotbeds of disease. But the century had grown older still before this thoughtfulness of some—and those indeed few in number, and possessed, unfortunately for the interests of the people, of but little of that commanding influence which takes hold of the public mind and brings about public action—had so far done its work as to cause others possessed of this influence to take up the study of the subject and give it a place amongst those public movements which are known to have a close and direct bearing upon the public welfare. But so far as the general public were concerned in this new and most important movement, it may with some safety be stated that it is only within a period of very little more than a generation ago that the full importance of the science which is called sanitary has forced itself upon the public mind; and that the details of the subject have taken such a commanding position as to raise their consideration to the dignity of a science.

Present Position of the Science of Sanitation.—Circumstances which brought it about.

That the position which the "science of sanitation," as it has otherwise been termed, has now attained, is not due to the exertions of scientific men considered purely as such, its history abundantly proves. Indeed, it may well be questioned whether, if the hold which the subject has now of the public mind had depended for its creation and its nurture solely upon what men of science as such did for it, that hold would not have been vastly more slender than it now happily is, and its initiation have been kept back for not a few years. But, fortunately for the interests of the people generally, coincident with, if not indeed actually antedating or preceding the exertions of men of science, certain philanthropists had taken up the subject, impressed chiefly with a sense of the importance of the fact that it was possessed of momentous moral and social principles, exercising a most potent influence upon the well-being of the population. With such considerations science purely as such has no concern; it deals only with material facts and circumstances, and endeavours to discover the laws, if laws there be, which govern and dictate the practical facts and outcomes of the case. But, happily for the progress of the whole question, the combination of the man of science with the philanthropist was, in the early days of the history of sanitary science, not seldom met with. And the result of this was, the representation of philanthropy as to the moral and social evils arising from the *in*sanitary condition of our houses, especially those in densely crowded districts, backed with the teachings of science as to the physical evils of this condition, gave a potency to all that was made known on the question, which compelled, so to say, not only a readier but a quicker appreciation and apprehension of its value by the public. It is, therefore, now well understood that the moral and social considerations connected with the subject, and those which are purely scientific, cannot be separated if we would, ought not to be if we could. And in place of this dual relationship acting injuriously on the progress of sanitary science, and hindering, if not in some cases wholly arresting, the work of the sanitary architect, it greatly and most efficiently promotes it. A subject of necessity possesses a greater value if we find that while its practical conception ministers powerfully to the health of the people, it also ministers no less so to the improvement of their social and moral condition. Hence arises the double influence which this subject of sanitary science exercises on our population, and the greatly increased importance of the work of the sanitary architect.

Twofold Aspect of Sanitation.

This view of the subject, the accuracy of which is not likely to be disputed even by those who may give greater prominence to its scientific than to its moral and social aspect, naturally divides its consideration into two distinct heads. The first of these is concerned with the moral and social points, the second with the purely scientific and constructive. And a notice of the first of these two methods of dealing with the subject, in place of lessening the importance of the details of the second, will be found greatly to increase it. This notice will in fact afford still more cogent reasons why those scientific details should be generally applied to the practice of house arrangement and construction. But in truth, as we have already said, the two sides of the question cannot be separated. We therefore, preliminary to the scientific and constructive details, take up briefly those which bear upon the social and moral welfare of the community.

It has only been within a comparatively recent period of our national history that the condition of what are known as the lower classes of society has been a subject for the consideration of those whose worldly good fortune it has been to be placed far above material want, and who in turn constitute the better classes. Isolated cases, no doubt, were met with in which some attention was given to the wants and woes of the very poor and the otherwise utterly neglected. But it seemed never to have entered into the mind of the public generally that the condition of those who formed the lower stratum—or rather strata, for in the lowest deep there was, and is, a lower deep—of the body politic and social, had in reality any practical concern with the vital interests of the community considered as a whole. The better classes, at the time to which we allude, certainly could not be charged with the fact that they were in any way their brothers' keepers, except in the sense of keeping those down who were down in the social scale, or at all events being careless as to their ever rising up in it—if, indeed, they were in anywise looked upon as brothers at all, whose welfare concerned them.

Social and Moral Aspects of Sanitary Science.—Important Elements in its Consideration.

It would be very useful if we could here find space to enter somewhat into detail as to the rise and progress of that infinitely higher interest which in time permeated through and penetrated the mass of the better classes of the community in the condition of those who in more senses than one were at the bottom of the social scale. No doubt the steps of progress of that interest which led in process of time to the remediary measures which have been the characteristic of the period of the last two or three generations, were at first taken at intervals few and far between; and were taken, moreover, very slowly. But if slow, progress was happily sure, thanks to the exertions of far-seeing and prudent philanthropists. Possibly the first real and practical step towards the establishment of a better order of things social was that taken by Howard, the prison philanthropist. Before that time very few seemed to have any idea that the unhealthy condition of the lower classes—the wretched state of their dwellings, in which and amongst which diseases of the most dangerous kind were never absent—had some influence on the health and well-being of those classes who lived under infinitely better circumstances of social life and comfort. But Howard did much in proving beyond any doubt that the evil influences constantly present and ever perpetuated in and amongst the very poor confined within the prisons, and by parity of reasoning existing also in and amongst the wretched hovels and districts—not less prisons—inhabited by the poor, exerted a power which in turn afflicted those who lived in houses and in districts which, from their in every way superior condition and position seemed to be wholly exempted from the causes which elsewhere gave rise to such foul and dangerous diseases. But what Howard did was to prove, in a way which startled the general public mind, that no class, however high in social position, and however well housed and cared for, could with impunity allow disease aggravated by direst poverty, and too often by actual want of the necessaries of life, to revel, so to say, in the houses and districts of the poor. What was done so well by Howard was followed up by others, till at last the public mind was awakened to the great truth that all classes of society, including the very lowest, were bound together with the ties of a common interest; and that what affected and injured any one class, in some and often in great and painful measure injured all other classes.

Practical Relation in a Sanitary Point of View between the Condition of the Poorer Districts and the Wealthier.

And although the public mind is in an infinitely more healthy condition than at one time it was, still there are many who do not yet see that there is a close connection between the condition of the lower classes, which tends to perpetuate both moral and physical disease, and the like condition of the higher classes, to one of which they themselves belong.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER I.

Introductory.

WORKSHOP and factory practice, in the wide range of technical and industrial work carried on throughout the kingdom, comprises a vast variety of details and of facts bearing on the operations and processes, which are of themselves exceedingly numerous. The space, therefore, which of necessity even comparatively brief papers descriptive of them demand, is so great that it is difficult to find opportunities to place before our readers others bearing upon the more abstruse points of the theories or of the principles upon which many of the branches of technical work are based. Nor indeed is this more purely theoretical matter demanded of us: the scope and scheme of our work, as in large measure indicated in the title of our Journal, and still more fully in the opening paper on "Technical Education," are designed specially to embody the facts connected with practice of the various branches of technical and industrial work. These may be here conveniently called practical illustrations of the theories upon which the details of actual work are based. In the various papers or subjects which will make up the body of THE TECHNICAL JOURNAL, those theories will be as a rule only incidentally referred to. In such cases attention will be drawn but very briefly to those points of practice which are defective because sound theory has been neglected or wilfully overlooked in the details. But while this is so, and while we should thus fulfil our obligations within the limits of the scheme of our work, we are so desirous to meet the wants or requirements of all classes of readers, and on which representations have quite recently been made to us, that we have now made special arrangements by which space will be found to enable us to give a series of papers bearing upon the principles of certain sciences, or explaining generally the theories on which certain work is based. Whether we shall be able to compass brief notes on the leading principles of several branches of science—and those are not a few in number—depends chiefly on space. At present, however, we have arranged for two of the leading sciences, known under the general titles of "Mechanics" and "Chemistry." We have decided upon those, inasmuch as the principles which they involve do not apply merely to one special branch, but to what is in reality a wide range of branches of technical work.

Scope of the Present Series of Papers—General Mode of Treatment.

Should we be able to compass no more than the present series, the reader will find, as just stated, that its various chapters will embrace the statement of principles which will cover not one or two merely, but many branches of technical and industrial work in their practical details. It is scarcely necessary to say that neither the scope of THE TECHNICAL JOURNAL nor the space we have at command for this series admit of that full treatment of the subject which characterises exhaustive treatises on it. What we give will take the form generally of what may be called a series of "notes" taking up various departments of the general subject. Indeed, all the practical necessities of the case will, we conceive, be fully met by those notes. They will embrace the salient or leading features which have a direct and immediate bearing upon practical work. The more abstruse and intricate disquisitions, which demand from the reader the exercise of intense study and the most painstaking care, and which in many instances require a knowledge of the higher, or at least the more difficult branches of mathematics, must for the present at all events be passed over. Some of those, in a few instances at least, and by some writers, are so beclouded by what are largely but metaphysical speculations, that the reader is apt to become confused and in large measure bewildered in attempting to understand them, or to decide between conflicting theories,—and of conflicting theories in general science there are not a few.

Applicability of the Laws or Principles of Mechanics to a Wider Range of Technical Work than that popularly known as Mechanical, or connected with Mechanism.

This at first sight, to the uninitiated or to the youthful reader, would seem to be confined to an exposition of the principles upon which the practice of mechanism, or what is popularly known as machinery, was based. Hence the name of the "science," so to call it, of mechanics, is so far unfortunate as leading to false conceptions of what its scope is, as if it were confined solely to that class of work just named, and with which the title in the popular mind is generally associated. But its scope is very much wider than this. While the mechanic who deals with machines or machinery concerns himself with those principles of the science of mechanics which refer to matter in "motion"—the mechanic who is concerned with structures, as houses, bridges, or the like, is interested in those of its principles which refer specially to matter in a state of "rest," or as it is otherwise termed, "stability." And at the same time there are certain principles or laws of nature treated of usually under the general title of mechanics which are applicable to the work of all, whether they be machinists, builders, or indeed a much wider range of artificers or constructors—using this latter term in its widest sense as embracing those who make up, put together, or build up the varied and almost endless objects with which we are surrounded. Nor does the application of some of the principles of the general science of mechanics terminate here—wide as that application is. They, in point of fact, most closely concern other branches of technical work. The chemist himself has to consider them, and they are exemplified and made use of in a wide range of that work which is known as Industrial Processes. If, then, to our notes on mechanics we add those on chemistry, we shall be able to present to our readers a variety of information of a very wide range of practicality. For just as the principles of mechanics apply to the practice of many more workers than those connected with machinery only, so will it be found that those of chemistry embrace within their range a great variety of processes which give rise to very important branches of individual industry. In concluding these introductory paragraphs, let the reader bear in mind what we have already stated,—that the "notes" we propose giving will concern themselves chiefly with those points which have a more or less direct bearing upon practice, and will not comprise the more purely theoretical disquisitions which are generally met with in works treating fully of the sciences. Further let it be observed by the reader that our "notes" will not be given upon any specific plan of arrangement. In special treatises the case for obvious reasons is different: there systematic treatment is always aimed at, although it be not in all cases secured. But it is right to state that while our notes will be given under various specific heads, they will as a rule be given so far systematically that one note on the subject of which it treats will in great measure so lead up to the subject of the note next to be given, that a fair degree of natural or systematic sequence will be secured.

Some Considerations as to Certain Terms used in connection with Mechanics or the Philosophy of Materials as distinguished from the Philosophy of Mind.

When we take into consideration the great variety of machines, especially if we have much to do with machinery, either in the way of constructing it, or employing it in one way or other of the many branches of that industrial work which practically constitutes the whole of the labour, as it is the source of the wealth, of the nation,—when we see around us in every department of life some evidence of what machinery does for us in the way of supplying our necessities, adding to our comfort or gratifying our tastes and liking for the beautiful and luxurious, —when we see even in the humbler walks of work, if not machines, at least mechanical appliances, which owe their existence and utilities to the work of machinists, or are, in themselves, more or less mechanical,—when we read and hear talked about everywhere and always of the wonders which machinery has done and is doing, and how much it has contributed to our wealth and influence as a people, we are very apt to look upon all this accumulated and what is really, *per se*, in and by itself, marvellous evidence of man's untiring energy and industry, as the result wholly and altogether of man's ingenuity and of the creative powers of his intellect. Nor is this conception in any way altered or even modified by what we consider and talk about art and science; very much rather is it intensified and still more settled in our minds as a fact or truth which cannot be got rid of or gainsaid. For in using or thinking about these terms of art or science, we just as readily and unhesitatingly define and decide that since those are the means or power by which all this wonderful accumulation of mechanical force has been created, they themselves —the art or the science are the product of man's inherent ability, no doubt built up, so to say, by the experience slowly acquired through a long series of centuries, but none the less the work, as they are the evidences, of man's intellectual power and untiring energy. Reasoning thus in a circle, we naturally come back to the same point, and therefore decide that, as all this mass of machinery existing around, and met with everywhere and everywhen, is dependent upon the arts and sciences for its creation and existence, as those are solely the product of man's ingenuity or intellectual ability, so also must be the machinery which he makes.

Natural Laws, or, as they are often termed, the Powers of Nature.—Popular Notions concerning them.

Now and then, but on the whole very rarely, do we find that, along with the words "art" and "science," another word, that of "nature," is associated. If used in conjunction with the others, it is but too often used in a totally subordinate sense, simply because in the popular mind it occupies but a very subordinate place. When we talk of the wonders of science, when we indulge in statements of what the arts have done for us, we associate with the terms a wide array of facts around us on which we greatly pride ourselves as the practical product of the one or the other. or of both combined, as they often are combined, as evidenced in the phrase now so familiar to us all—"Art manufactures." But when we talk of the powers of nature, we have but very vague and indeterminate notions of what those powers are. Popularly, indeed, it may be said that they are looked upon, at the best, but as powers of no great practical value, and associated chiefly with the everyday phenomena of what are called natural circumstances or occurrences, such as rain, wind, thunder, sunshine and clouds. And to those who have listened to a lecture upon science so called, and to a bright-coloured exposition of what art is capable of and can do for us, it would be a matter of no great surprise to be told that upon the laws of nature all science depended; to this they would give an easy sort of general consent, not caring much, at least, to dispute the statement. But it would be a matter to them of very great surprise indeed to be told that all of the complicated, as well as the wide, almost endless, range of simpler, but in their way as useful, mechanical appliances depended upon those very "laws of nature" of which they had taken but little account.

Apparent Infinity or Endless Number of the Laws regulating and controlling Natural Phenomena.

While others would, however, having formed a more accurate notion of how things really are in the relation of nature to science or the work of man generally—for in the truest sense of the term all man's work is scientific—be disposed to accede to the truth here stated, they would, as a rule, be apt to associate with the term or phrase "laws of nature" —to which they would be willing to accede the greatest power and influence in all that concerned man's natural existence—the idea that these laws were so numerous as to be quite bewildering, and that if a knowledge could be obtained of them its acquirement would be the labour of a lifetime. This conception, which may be said to be the popular one, may easily enough be accounted for when we consider the fact that the phenomena of nature, numerous and endless as they appear to be and in great measure are, are themselves taken each individually as the exponent, so to say, of a separate and distinct law. There are others who, having a more accurate view of how matters stand, would, however, be ready enough to see that a great number of what appeared to be separate and distinct phenomena might or could yet be classified as derived from one law; so that possibly the whole of what are called natural phenomena or occurrences might be ranged under general laws but a few in number.

The Varied and Varying Phenomena surrounding us are all Subject to but Two Great Laws of Nature.

But they would be very much surprised to be told that these laws are so few that to tell them off on the fingers of the hand these fingers would be so far from being exhausted that only two would be taken up. And this is really so; for each one of the indefinitely varied and varying phenomena which we call "natural" being one of the movements of what we call "science," all the effects of what we designate "art" come under the effect of one or other of two laws only, and which are therefore well and significantly called the two great laws of nature. What these laws are, and what the phenomena which they exhibit, upon which the work of the mechanic depends, we shall see as we proceed. The mere bald statement or naming would at present serve rather to confuse than to make clear what can only be made so by a more systematic treatment and a greater closeness of detail. Suffice it here to say, as in itself a marvellous statement of what controls the wonders of nature, that upon the laws which promote the growth of plants, create the breezes which blow over them, and give to the moisture which rests upon their leaves the form of the dewdrop, depend not merely all the other "phenomena" to which we give (somewhat wrongly, however, as we shall more fully see) the name of "natural," but the "forces" which we call (as wrongly again) "motive powers," by which every machine we use is set to and kept in work, and every motion by which that work is done, and all the distinct peculiarities and characteristics of the materials of which the parts of the machine are made, and of the substances on which they operate.

Incalculable Value of the Material Work done by Man in availing of and applying the Great Natural Laws.

What has been said materially modifies the popular conception that all the varied work of the machinist is the outcome of man's own ability to design and to construct, as if each were by itself a distinct and separate result of his intellectual power, having its own laws and its own characteristics as quite apart from some general law regulating other departments of his work. Or this other conception, that while the laws of nature have had some share in the work, by far the larger proportion of it is due to man, and the power of his mind and the energy of his inherent natural powers. But while what we have said does thus materially modify popular conceptions, it does not lessen, but rather *per contra* enhances the value of, as it certainly, rightly regarded, greatly increases the wonder at, what man has by the value of this mechanical work done for humanity at large, and—taking a more limited and prevalent, if it be a more selfish view—for our own people. And of this work it would be almost impossible to employ laudatory terms so high that they would be called exaggerated. For, in truth, it is impossible to overestimate the value of what man has done in mechanical work; and so far from detracting from all we have said, it enormously enhances the value of it when we consider that it is all based upon two laws, numerous though the phenomena be which come out of or arise from or depend upon them. For if we remember the broad fact, which will be a little more particularised presently, that man *has had everything to find out* in connection with the doing of what is called work upon which his very existence depends, and this from what existed around him, nothing of which, so to say, told its own tale on the face of it, we may form some faint conception of what his work has been. We say faint conception, for it is only by endeavouring to trace out from the earliest times what man *must* have had to do before he could make even the smallest approach to the present condition of things, that we can arrive at a fair idea of the value of the work he has succeeded in doing.

General Character of the Work done by Man.—Its Primary Element.

And all this which man has done for himself, reduced to its simplest, to its primary or essential elements, may be, as indeed it is most accurately, defined as "work to be done." And this by availing himself of the laws of nature, through certain adaptations of material substances, to which certain forms have been given. What this adaptation demanded from man is, may in some measure be understood from what we have said—that he had *everything* to learn concerning what he was surrounded by. In the minds of many, even of some of those who are really skilful mechanics, so far at least as construction is concerned, the adaptation of the laws of nature to the work of the machinist is only associated with the combinations of parts of the machines, with what are called their "movements," and with the force or forces by which the motion of these parts is first created or brought into existence, and then maintained or supported so long as desired. It is by many forgotten and overlooked, and by not a few unknown, that the characteristics or peculiarities of what are called materials—the parts, in fact, which distinguish one object from another, which tell man that one material is different from another—depend equally upon the laws of nature which control and regulate forces and motions. So that of the very materials by which the simplest mechanical help he made was formed, he would at first be wholly ignorant. So also of the substances with which he had to deal, and the "elements," as they were and still are called, by which he was surrounded. So accustomed are we to deal with all those in such an infinite variety of ways, so completely do we make them subservient to our various wants and wishes, that it is difficult for the popular mind to understand how there could be any difficulty in knowing all about them, and how it actually took long ages of patient observation and of painful experience before man go a really practically available knowledge of them. And to some it will be a matter of great surprise to be told that of some of them we even yet, after all we have done, know but a little, and of others that all we do know of *what* they really are is that we know nothing, and, so far as present appearances go, the likelihood, the almost certainty is, that we shall never know.

A Knowledge of the Laws of Nature, and the Capability to apply them to his Practical Work, acquired by Man only after Centuries of Patient Observation and Experimenting.

To put it paradoxically, we say, all that we do know is, that we know nothing. But this must not be misunderstood. Although we do not know what certain things are, we know what phenomena they exhibit, and, what is of infinitely greater importance to mankind, we know what they can do for us. But to get to the knowledge of all this is just what has constituted the work of man in making the laws of nature subservient to his purposes when applied in certain ways, and adapted, so to speak, to certain circumstances. Thus, we talk about that to which we give the name of *light*; but the ablest and the most acute of our scientific men, if asked to say or explain *what* it is, is obliged to confess that all he knows about it is, that he knows nothing absolutely: there is more than one theory on the subject; but as to which is the right one, all that can be said is, that much can be said on both sides. But if asked, on the other hand, if he knows of its phenomena, or of the laws which regulate those, he can point with pardonable pride, as evidence of how much he does know of them, to what by their aid man has done with the telescope in revealing the wonders of the infinite space of the heavens; the microscope in revealing the no less marvellous wonders of the earth; to the lighthouse, and to the marvels of photography, and many other branches of man's work. The same with electricity: we can but stand humbly aside, and when asked if we know what it is, confess that we know nothing. But we can, as in the case of light, point with satisfaction to what our knowledge of its phenomena and of the laws on which they are dependent has enabled us to do in the marvels of the electric telegraph and the telephone; and it is difficult to say what it will yet do for man as a motive power. All this is no less true of *heat*; and the work man can do with it is even more marvellous, as it is infinitely more diversified in its applications, than what he has done with the agencies of light and of electricity. How all-pervading this agency or law of heat is, and how of it it may be said that it is the measure alike of man's life and of all the work he does, no matter how diversified it may be, and how that heat, life, and work may in some sense be said to be synonymous or convertible terms, we shall see more clearly as we proceed to explain the two great causes on which all natural phenomena depend.

But this arrival at knowledge of natural phenomena, and of the laws which regulate them, was gained only after centuries of patient observation and still more patient working and experimenting. So much accustomed are we to see around us evidences multiplied a hundredfold of the work done by the application of these laws, that we rarely give a thought to the fact that it took centuries in the history of man before he had accumulated a sufficient knowledge of the phenomena, and devised a variety of contrivances by which these laws were deduced, and their working illustrated.

Every mechanic, for example, knows what is done by taking advantage of the principle of atmospheric pressure—the very name of which, as even the most youthful student knows, indicates that it—the atmosphere or air—must be a substance or a body (to use a term which demands, and will hereafter receive from us, a fuller explanation, as it is air which plays an important part in all scientific disquisitions) which is able to exercise a power or exert an influence of a physical or material kind. Yet the young student may be surprised to learn that for ages men lived in ignorance of this great truth or fact—so long a period, indeed, of his history, that it is but little more than two hundred years ago since an Italian discovered the law which regulated atmospheric pressure, and opened the way to that practical application of it of which we have an almost endless series of exemplifications in our machines, instruments, and mechanical contrivances.

The Work of the Practical Man dependent upon the Laws of Nature; long preceded in Early Times the Knowledge of the Theorist as to those Laws - Practical Exemplifications.

And this very circumstance now noted is a curious exemplification of a truth which so many overlook, and to which many have never given a thought—namely, that as a rule the contrivances of man actually put to do certain work, and which were in fact dependent upon certain natural laws, have preceded the labours of the man of science, by whom the laws have been, so to say, scientifically discovered and enunciated upon which those phenomena depended, and in virtue of which those contrivances were successful for the object had in view. Thus, for example, although man for ages knew nothing of the law regulating the phenomena of the atmosphere, he had got so far acquainted with its peculiarities that, where prompted by his necessities, he had worked out the contrivance known as a "pump," by which he could lift water to a height from a low level. In the working of this most useful contrivance, men knew that as the plunger was lifted or raised the water followed it closely, leaving no space between. Why it did so they had no conception; but as man is impelled by something within him ever to be seeking for "reasons why" (if the reader will but think it out, one of the wisest dispensations of an ever-wise Creator for the advancement of man's civilization), he gave this as the reason for this action of the pump—namely, that "Nature abhorred a vacuum," that is, a space containing "nothing,"—which would have been the case had the plunger continued to rise in the barrel or tube of the pump without the water following it. When men—and the characteristic is as powerfully existent now as then—get hold of a reason which apparently satisfies the conditions, they readily enough accept it, and keep to it till something turns up in the range of practice, compelling them either to modify it, or to abandon it and find some other as its substitute. And as supposition is always resorted to when men in reality do not *know* what is the truth of the matter, they can but conjecture only; and, conjecture being easy, we find enough of it has always been in existence, and no less exists now than in the darker ages of man's history. We can, therefore, in this matter of the invention of the pump, easily enough conceive, from the very nature of the circumstances in which man in the early stages of his civilization was placed, the difficulties he had to deal with in the employment of materials, his lack of tools to fashion and form them, that pumps would only be used for "short lifts," to use a technical expression now commonly in use to denote the vertical height water is raised from a low to a high level. To make a long barrel, we may be certain, was for ages beyond the possibilities of mechanical work; and it was only when the range of this had increased that the reason for the action of a pump, which before satisfied men, had to be modified. For it was about two hundred years ago that a pump larger than usual was fitted up; but it was found that by no method of working it could the water be lifted, or "drawn up," to use a common expression, beyond a given height—thirty-four feet. A new reason had then to be given for this new condition of things in the working of a pump, and it was a mere modification of the old one—"that Nature abhorred a vacuum, but *only* beyond heights or lifts of thirty-four feet." This the youthful student will see was only putting forward the difficulty to some other point, and what that was, and when and how it would be reached, no one seemed to know or care. This mode of dealing with the difficulty—acted upon not seldom, we may also say, even in these the days which we so proudly call "advanced"—did not satisfy the "men of light and leading," of whom fortunately more than one lived in the early times we write of. It did not satisfy one thinking mind, who by patient "thinking the matter out," and by as carefully conducted experiments, discovered the law of atmospheric pressure, which at once set aside all conjectures and so-called reasons, and established a branch of science—truly so named—which has been of such wonderful benefit to mankind.

SUPPLEMENTARY SECTION

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

16. Belting and Gearing as Transmitters of Power.

THOSE who have had opportunities to see machines at work in which toothed-wheel gearing is wholly employed for the transmission of power or the communication of motion, are aware that their working is always accompanied with a greater or less amount of noise and jarring, and that this, even where the best of work is met with, is always more or less perceptible. In the case of belting and rope driving gear the most noticeable feature to the inexperienced is the quietness with which the belt or rope travels even when travelling at great velocities. And even to those of this class it is at the first obvious that toothed-wheel gearing, in order to work with the maximum of good mechanical effect, will require to be designed and constructed with a higher degree of mechanical care and knowledge; in other words, that it will be a more complicated work to apply it to the driving of machinery than to apply belts and ropes to effect the same purpose, which even to the tyro in mechanics convey at once to his mind the idea of simplicity alike in principle and its modes of practical application. Nor less easy will it be for him to decide that toothed-wheel gearing is not applicable to the driving of machines at the very great velocities which he sees to be the characteristic feature of so wide a variety of modern machines.

17. Peculiar Features of Belting as a Transmitter of Power.

In the technical language of practical mechanics the toothed wheel or the pulley which gives the motion is called the "driver," that which receives it the "driven." Wherever in machines of any kind there is to be a precise proportion between the speed or surface velocity of the "driver" and the "driven" maintained — that is, where the driven must turn or revolve so many times, either greater or fewer than the driver, but always in the same proportion—then the toothed-wheel gearing must be employed. In the case of belt and rope gearing this precise, definite, or exact proportion cannot be secured, not merely because it is not practicable to construct the pulleys with the absolutely perfect relative proportions required, but because from the very nature of the way in which the motion of one is imparted to the other through the medium of the belt, which is due to the frictional adhesion of its surface and that of the pulley, a certain amount of "slip" takes place, which may be small in amount and uncertain in action. But in the great majority of instances the slight or comparatively slight variations in the relative velocities of the driving and driven parts are of no practical moment, so that belt and rope gearing is applicable; hence the infinitely greater number of cases in which these systems are employed, as compared with the more complicated system and the less smooth and easy working of toothed-wheel gearing.

18. Relation of the Belt to the Driving Pulley.—Coming off of the Belt in Working.—Points connected with it.

Taking into consideration the fact that the driving belt is flat on its surface, it might be supposed that it would "run" best upon a pulley the surface of which was also flat—that is, in which the face was a straight line at any point across the surface of its periphery or ring. The young mechanic will of course understand that a "pulley" in driving gear consists of a ring, or what is known popularly as a hoop or rim of greater or less breadth, and which is connected with its centre or "boss," through which the shaft passes, and to which it is secured by arms—also popularly known as spokes—and in the case of small-diametered pulleys with a thin plate or disc, known technically as the "web," the whole being cast in one piece. The surface or face of the rim or hoop is of course at right angles to what may be called the sides of the pulley. We have said that at first sight it would appear that if this surface were a perfectly straight line across it, the belt would run best, seeing that its surface is also straight—the two flat surfaces being then in contact at all points, being parallel. And as the efficiency of belt driving gear depends not only upon the speed with which the pulley revolves, but upon the adhesion between the surface of its rim or hoop and the belt passed round it, it would appear that this adhesion, or "grip" as mechanics term it, will be better attained when there is a parallelism between the two surfaces—that of the belt and the rim—than when the belt touches or runs upon part only of the rim—so much of the grip due to the whole surfaces being thus in the latter case obviously lost. But those who have had much to do with belt driving gear know the trouble which often arises from the belt coming off the pulley. This coming off from is a different thing from the slipping of the belt on the pulley, which slipping will be noticed presently. Now—and this it will be perceived, is quite opposed to the above consideration, which may be said to be the theoretical condition of a pulley surface and that of the belt—in practice it is found that this coming off of the belt during the running is prevented by having the rim of the pulley made convex—that is, with a rise or swell in the centre of its breadth. The convexity is of course precisely in the centre of the breadth of the rim of pulley, and gradually and uniformly on both sides curves down to the sides or edges. In other words, taking a cross or transverse section of the rim or periphery of the pulley, it forms part of a circle on the outside surface. The pulley rim or hoop may thus be considered as a double cone, the highest part of the cones—right and left—meeting in the centre. In a pulley thus formed, it is found that a driving belt has a tendency always to run on and creep up, so to say, to the highest part of the convex rim—that is, towards its centre, and therefore to keep on, not to slip from *off* the pulley. No end of theories have been offered to account for this tendency, but the practical man is quite content to know that it exists as a fact, and it is with facts, not with theories about them, that he is also generally satisfied. But it is always best to know the reason why of things; and theory, beyond any doubt, has often led to the discovery and establishment of practical facts or circumstances. The exact reason why a driving belt has always a tendency to run on the highest point of the pulley rim cannot be stated, simply because it is not known; but the following, of all the explanations given or theories formed, is perhaps the best. As we have said, the convex surface may be considered as a double cone—a right and a left cone—the outer edge of each cone corresponding in position to the outer edge of the driving belt. Now, "that edge of the belt which is towards the larger end of the cone" (that is, we may remark, towards the centre of the rim where the two large ends of the cones meet) "is more rapidly drawn than the other edge" (that is, has its velocity onwards greater), and "in consequence of this, the advancing part of the belt is thrown (or drawn) in the direction of the larger part of the cone (that is, towards the centre of the rim); which obliquity of advance towards the cone must lead the belt on to its higher part." But this convexity given to the pulley rim has, in addition to its great use in keeping the belt on the pulley during its driving, another advantage which it is right to notice.

19. Grip of the Belt upon the Pulley.—Its Relation to the Convexity of the Rim or Hoop.

We have said that the way in which the power is communicated from one pulley to another—that is, from one machine to another, or from the main driving power or motor to any given point—is due to the "grip" which the belt takes of the pulley, or, conversely, the pulley of the belt. But this very grip, which constitutes the value of the belt driving system, is in itself a source of safety in using the power as well as in giving the power itself. For should anything occur in the working of the machinery driven by the belt or belts which throws such an additional strain upon the parts that damage might follow if the strain by the continued driving were kept up—the strain being so great, it overpowers, so to say, the "grip" or frictional adhesion between the belt and the pulley. And the result is that while the pulley continues to revolve or "run," it simply revolves *within* the belt, and does not grip it—the adhesion not being able to overcome the strain upon the belt. This, of course, happens at both pulleys—the driven and the driving—so that the driven pulley no longer has any grip upon the belt, and thus the machine ceases to work well. The breakdown is thus prevented which otherwise might have taken place had the power been kept up while the extra strain on the machine existed. Now here comes in the other peculiarity of the convex surface of the pulley rim; for it is found that when the resistance to the working of a machine increases to a dangerous point, the tendency of the swell or convexity is no longer to keep the belt on, as we have seen that it is under normal or safe conditions of working, but on the contrary to throw it off. So that in belt driving we have thus two safety sources in cases where extra resistance is increased—that is, beyond the safe working point of the machinery, and where the pulley moves round without dragging the belt, or where, to use the technical phrase, the "belt slips." While giving purposely a convexity to the outer surface of the rims of pulleys for the purpose we have named, the young mechanic should be careful to give only the minimum or requisite degree. For it should be remembered that all deviation from the perfectly flat or straight-lined rim surface brings about a loss of power, the theoretical form of the pulley being a cylinder in which the diameter is equal at all points. It is the object, therefore, to know what percentage the "rise" or convexity of the rim should bear to its breadth or distance from edge to edge. Several authorities are found who have recorded their views on this point; and it need not be a matter of surprise to learn that there is some diversity between the proportions they recommend. This, however, is not so great as exists in other mechanical points. Thus the proportion of rise or convexity varies with those authorities from one-eighth to one-tenth of the breadth of face of rim. A rise of one-twelfth may be taken as a safe proportion. This will give a rise of two-eighths or a quarter of an inch for every six inches of breadth, or, using the ordinary standard of a foot, half an inch to the foot. Some authorities give, however, much less than this—so much less that they only allow one-fourth of it, or an eighth of an inch to the foot. This we believe to be far below the safe proportion, and would recommend the half-incl to the foot as being the best; it is at least based on an investigation of a great number of successfully driven or driving pulleys. In our next Note we shall go into other points connected with the pulley.

20. Ornament in Relation to Particular Applications—Fitness, Appropriateness.

In thinking over the application of ornament to the "beautifying" of objects manufactured or made or constructed, the art student should carefully consider what is the work he is proposing to do. It is essentially necessary to remember this: that any particular class or style of ornamentation, or any one design, may be in itself beautiful,—that considered simply as a design it may be, so to say, very attractive and lovely,—and yet that it may, when applied to any one particular purpose, be so ill adapted to it, that the incongruity between the ornament and the object ornamented will be so startling and offensive, that all sense of the beautiful which the ornament *per se* or by itself is calculated to create, will be lost, or largely so. In such a case it is at once seen that there is a lack of "fitness"—in other words, that the design is not "appropriate" to the object, or the converse, the result in either case being practically the same—an incongruous object. No doubt, a certain degree of educated taste, or amount of art knowledge and experience in art decoration, is required to enable one at once and with accuracy to decide that a given design or piece of ornament is unfitted for a certain object, even in cases where the incongruity will not be observable to a less carefully trained eye. Still it is but too true that the instances are very numerous indeed in which the incongruity between the object considered in relation to its uses, and the ornament by which it is decorated or beautified—so called—is so great and so marked or pronounced that it strikes even those who are ignorant of any of the points of art education. They are clearly conscious that the object is not beautified, although they may not be able to point out the reasons why it is not decorated in the true or art sense of the term. It may be accepted as a rule having few exceptions, if indeed it has one exception, that there is, for any particular object which is to be beautified or decorated by ornament, one particular style or class of ornament which is fitted for or appropriate to the object—this and no other—so that it would be unfitted for or inappropriate to any other object or use. The art student will perceive, on consideration, that this truth or axiom lies at the root of all art "design," for it obviously implies that thought, without which there can be no design in the true sense of the term, must be given to each particular case. For as each varies in its peculiarities—one class of constructed or manufactured work being quite different in its characteristics from another—each will demand, on the principle we have set forth, its own design which shall be fitted to or appropriate for it, since it is the exercise of skill, or rather of art ability, possessed by the designer which decides whether his design is perfect or otherwise. This thinking out of the design, when carefully and honestly pursued, is the only way to avoid the glaring mistakes which are but too frequently made in applying ornament to manufactured or constructed objects. There are certain rules or leading principles which apply to this inherently valuable principle in design, fitness or appropriateness or congruity in relation to various manufactured or constructed objects. These may be said to cover the whole subject of art design, and to them will be devoted future occasional notes in this section or division.

21. Ensilage.

We preface the practical notes we purpose from time to time giving on this subject, which is one engrossing the attention of the farming public, by the following brief statement of the general features of the system.—The principle involved is the placing of green cut food, as grass and other succulent farm produce, in a mass, so that the external air is excluded from penetrating to and passing through the produce, and falling rain or snow from reaching it from above, and drainage water from the sides and bottom. The first of these points includes the close packing of the material, and the placing of it in a water-tight and roof-covered receptacle. This principle is familiarly illustrated in the domestic tin box or jar with close-fitting cover, in which tea or coffee or other substance of which it is desired to preserve the aroma is stored to keep it dry; more closely in the case of the domestic jam or preserve pot, and still more accurately in the case of the German mode of preserving cabbages known as sauer kraut. But the carrying out of the principle on the large scale in the farm is a matter of considerable difficulty, and involves the consideration of several constructive details, about which there is considerable diversity of opinion. This is not to be wondered at when we take into account the varying circumstances under which those who have adopted this system of preserving green cut food have had to adapt their constructive appliances; and how the experience of one farmer in a certain locality may have afforded facts differing so much from those obtained by another farmer in a different locality that the results of the two would seem to lead to conclusions altogether antagonistic. But this contrariety is only apparent, merely affecting sundry details, and in no way touching the inherent principle of the system.

In taking up its practical details, the first point to be considered is the way to prepare the receptacle for containing the cut food, and which we have seen must practically be air-tight and water-tight, but, of course, not absolutely so. The simplest form of containing receptacle is obviously a pit dug in the soil—this being the first form in which the silo was made, and which may be looked upon as the primary or elementary one. But while the easiest mode and the cheapest, it is obviously very incomplete. The bottom and the interior surfaces would, according to the nature of the soil, make the portions of cut food pressed up against them more or less dirty and unfitted for feeding cattle with; although on this point it may be said, as overcoming this objection to a large extent, that cattle and horses when out at pasture do and must take up with the grass considerable portions of soil or earth. Some farmers, believing that the soil passing into the stomach in this natural way is good for the animals, object to washing turnips, for example, preferring to give them to the stock just as they come from the field or the pit, with such soil as may naturally adhere to the roots. We name this as showing the technical student that points in practice should be looked at in different ways, and that it is dangerous to be dogmatic. But if a preserving pit, dug in the simple way we have described, be not objectionable on account of the point we have now stated, it is obvious that it will be so on account of its not fulfilling the requirement of being water-tight; for the sides or inner surfaces will act in great measure as draining surfaces, leading the water present in the soil for some considerable distance round the excavation to its interior. The pit under ordinary circumstances would, in point of fact, act very much as "trial pits" in drainage works; and would ultimately become filled with the water penetrating through the soil of its sides, or welling up through that of its bottom. No doubt it would be found in practice that this untoward result would be relative and conditional, dependent upon the nature of the soil in which the excavation is made or pit dug. In a loose, friable, or light soil, the mere surface water or rain falling in the immediate neighbourhood of the pit would pass downwards and drain rapidly into its interior, to say nothing of such water as might not be arrested by the ordinary tube or tile drainage (see "The Land Drainer") of the field in which the silo pit is dug. But in heavy, close and retentive clays the drainage into the interior or the percolation of the water through the sides of the pit would be much less in an equal space of time as compared with the pit in the light and porous soils. Yet the pit, even in such close retentive clays, would still be far from meeting the requirements of a good silo, for if the reader will turn to the paper entitled "The Land Drainer" he will find that water will find its way through even the densest of clays, and that even where the excavation, as a drain cutting, is very deep.

To meet, then, the requirements as shadowed forth in our statement of the principles of the silo, it is obvious that its sides and bottom must be, at least in large measure, water-tight; so that drainage water shall not be permitted to pass into the interior. There is a wide variety of ways in which this can be done. The most simple of all is to line the bottom and sides with boarding or planks; in the placing of which some thought is necessary. If laid edge to edge, the joints at the junction of contiguous planks will be pretty open, even if the edges be dressed with the machine or planed by hand. And if, to get a more water-tight joint than this, the boards are made to overlap at one edge, care must be taken to place the boards vertically at the sides. If they be laid horizontally, the young technical reader will perceive that as the green cut food is pressed down into the pit—and, as we shall see, great pressure is demanded—the "overlaps" at the edges of the boards will form a very uneven surface for the green cut food to slide down over. And if, as the very worst way in which to place the lining boards at the sides of the pit, this "overlap" is made with the upper edge of the lowest board covering the lower edge of the board immediately above, a series of projecting shelves, so to call them, will be formed, each of which will be an opposing surface to the easy pressure of the green cut food as it is pressed down into the silos. We name these points, as we for obvious reasons wish to get the young technical student to think for himself about points which affect the doing of work of all kinds, as well as to become acquainted with the details of any special subject. It is to be remembered that our work has for its aim not merely to be descriptive, but to be educational—not simply to show the details of some special work, but to explain the principles which affect all work generally. In our next Note we shall take up some of the remaining points of the ensilage system.

22. Non-poisonous White Pigments.

White lead still remains, as was referred to in a preceding Note (13), notwithstanding all that has been said of its poisonous properties, the most useful of pigment paints, and the most extensively used. Several substitutes of a non-poisonous nature have been tried, with more or less success in certain cases. For most purposes, however, white lead has not yet been equalled; all its substitutes possess less "body" or solidity and brilliance of colour.

Another disadvantage possessed by white lead considered as a paint is its property of blackening on coming in contact with sulphuretted hydrogen, as contained in coal gas and other sources, such as sewage. In the case of fine artists' colours this is a very serious disadvantage, and in most cases it precludes its use altogether in artists' colours. Both these disadvantages are absent in the white pigments which to a certain extent replace white lead, and which are moreover cheaper than the latter

—namely, sulphate of baryta, and zinc white or oxide of zinc. Both of these pigments are, however, much inferior to white lead in covering power or body, whilst they are no better as regards whiteness. Of these two latter pigments zinc white is more valuable as a paint than baryta, and is more extensively used than the latter. White lead, cheap though it is, is liable to be adulterated with sulphate of baryta, and its value thereby decreased; this may readily be detected by treating a small portion of the sample with strong nitric acid: pure white lead dissolves completely to a colourless solution, that mixed with baryta white leaves a white residue of the latter pigment.

23. To calculate the Contents of Cisterns or of Iron Tanks.

Quite recently this happened in one of our largest and best-conducted establishments, carrying on one of the most important departments of textile industry. One of the staff of upper officials, a man of eminently scientific attainments, was going round the works with a special object in view. His attention was attracted to three men, two of whom were sturdily emptying a large iron tank or cistern containing water, one of the three checking off each time the vessel for baling out was filled. Struck with the business-like way in which so common and what seemed purposeless an operation as this was carried on, the official waited the few minutes necessary to complete the emptying of the tank. He then inquired of the third man, who happened to be a foreman or overlooker of a certain class of work, what the object of the process was. As if surprised at so unnecessary a question being put, he answered, "Why, to know how many gallons the tank held," looking very much as if he would have liked—had he dared—to have added, "Now then, stoopid!" "Do you know the size of the tank?" "Oh yes," replied the foreman, and forthwith rattled off the dimensions. Taking out his memorandum-book, the official scribbled a few figures, tore off part of the leaf, and handing it to the foreman said, "That gives the number of gallons the tank can hold. Is the number the same as you have made it out?" Allowing for some difference in the filling of the emptying vessel and for "slops," the results were practically the same. The overlooker was somewhat surprised at the result, but seemed a little ashamed when asked if he was not acquainted with such-like rules or methods for ascertaining facts useful to him in his daily work much more quickly and indeed accurately than by the use of rule-of-thumb methods. Now, although we are far from saying that such is the general technical educational condition of many foremen or workmen in superior positions, there is no doubt that there are not a few throughout the kingdom who trust only to such roundabout methods of doing work; while there is still less doubt that this is the technical educational condition of a great number of ordinary or journeyman workers. We purposely cite the case as here given, but we could parallel it with cases drawn from many branches of technical and industrial work—as, for example, these. A decorative artist, who thoroughly knew the scientific points of his work, made an old grey-headed painter stare when he told him that he would find the result of a certain mixture of colours to be such as he—the old painter—asserted roundly could not possibly be. "As if I, who have been painting and working with paints for the last sixty years, weren't likely to know!" But for all that he did not. No more than a practical workman - a foreman, moreover —in one of our largest dyeing and printing establishments, who also had grown grey in the service of the works, knew why or how it was that a certain mixture of substances would give a certain shade of colour or dye, or *how* it was that a slight variation in in the substances, or the addition of a certain other substance in even the smallest quantity, would completely alter the shade. He knew—no one better—what certain work would give, and all the details as to the doing of it; but groping, as in the dark, knowing nothing and not caring to know anything about the "reasons why," he had never been able to suggest anything which added to the working capability of his department. Every improvement in it had originated with men to whom he would have denied the right to be called "practical."

We are not likely in the future to preface any of our facts, figures, or memoranda with anecdotal matter, such as that we have now given. But we do it now —and very probably once for all as it is a graphic way of "hitting a blot," or showing a thoroughly "weak point" in the condition of many of our technical and industrial workers. Engaged as they are from day to day in work which they cannot possibly be ignorant has derived every improvement, every new process, every new apparatus or kind of machinery from men of science the very class they are so disposed to look down upon as not practical—the real marvel is that they should have so worked on for years without some desire to know something of those sciences to which as mere workers for wages they owed so much. In their foremen, their managers, and in the heads of their establishments, they have beyond all manner of doubt examples of men who have risen to those positions largely, if not chiefly, by the fact that in addition to the usual qualities of prudence, steadiness, and close attention to work, they have studied the principles upon which the paying practice of that work depends. And it is no less a marvel that so many should nevertheless have shown so little desire to avail themselves in like fashion of this power of progression in life. That things are becoming every day different to this, is matter for the highest gratification to those who are truly interested in the progress of technical and industrial work, and in the advancement of the position of those who carry it out practically in our workshops and factories. We trust that in this great object of the future our Work will play an important, at least a highly useful part.

Let us turn to the subject named in the title of our paragraph, after this introduction, the length of which will not be lost if it should prove practically suggestive to some at least of our readers. (A) To find the number of gallons which a cistern or tank of given dimensions or size will hold or contain. Reduce the dimensions if in feet, or in feet and inches, to inches; as 9 feet 6 inches, thus $9 \times 12 + 6 = 114$ inches; then multiply the length, breadth, and depth, this taken in inches, into each other—that is, the length multiplied by the width, and the result, or quotient, multiplied by the depth. The final result will be the number of cubic inches contained within the dimensions of the tank. As there are 277¼, or 277·25 cubic inches in a gallon, divide the result or quotient last found by 277·25, which will give the number of gallons the tank contains. (B) To find the number of cubic feet, or the capacity—frequently termed the cubic capacity—in a tank or cistern of given dimensins. As before, reduce all the measurements in feet, or in feet and inches, to inches; multiply length breadth, and depth into each other, and divide the result, which is cubic inches as before, by 1728—the number of cubic inches in a foot—the quotient wil be the number of cubic feet required. And as there are 6¼ gallons of water in a cubic foot, the number of gallons will be found by multiplying the cubic feet by 6¼. Thus this method may be used as a proof of the correctness of the calculation (A). In some cases a tank or cistern may have to be fitted up in order to contain a certain number of gallons in a space of which the length and width are definite and must be adhered to, but of which there is no limit to the depth. This rule, then, may be employed to ascertain the depth under these conditions. (C) Take the number of gallons the tank or cistern has to hold, and multiply it by 277·25; divide the product by the length in inches; this multiplied by the width in inches, the result or quotient is the depth in inches. The conditions under which the tank or cistern is to be fitted up to contain a certain number of gallons may be such that, the length and depth being definite or fixed, there is ample space for width. In this case the following rule may be used. (D) Take the number of gallons and multiply it by 277·25, as before; divide the product by the length in inches multiplied by the depth in inches: the quotient will give the width in inches. Finally, the conditions may be such that, the width and depth being definite or fixed, and the number of gallons known, the length of the tank or cistern is required. Then in this case—(E) Multiply the number of gallons by 277·25, divide by the width in inches multiplied by the depth; the quotient is the length in inches. Taking the letter (l) to denote in the above the length, (w) the width, and (d) the depth, (o) the constant 277·25, (p) the constant 1728, (s) the number of gallons, and (t) the number of cubic feet, then the rules named above may be represented by the following formulæ:—

(A). $(l) \times (w) \times (d) \div (o) = (s)$.
(B). $(l) \times (w) \times (d) \div (p) = (t)$.
(C). $(s) \times (o) \div (l) \times (w) = (d)$.
(D). $(s) \times (o) \div (l) \times (d) = (w)$.
(E). $(s) \times (o) \div (w) \times (d) = (l)$.

(F) In cases where the tank or cistern does not rest upon the ground or a solid foundation, but is supported by beams or upon columns or pillars, it will be necessary to know the weight of the tank with its load of water—one of the data required to ascertain the dimensions of the beams or columns. This total load will be made up of the weight of the tank or cistern itself when empty, and the water it holds when full. The methods of calculating the weight of the empty tank will form the subject of a future Note, and the calculation also required to ascertain dimensions of beams or columns. We have now to concern our selves only with the weight of the water. The number of gallons being known or ascertained by the rule (A), this is to be multiplied by 10, the number of pounds' weight of a gallon of water—presuming this to be the liquid stored up. The product must then be divided by 2240, to reduce it to tons; the remainder by 112, for the cwts.; the remainder by 28, for the quarters; and the final remainder will give the pounds; the result in tons, cwts., quarters, and pounds will thus be obtained. N.B.—It will be observed that the above rules refer to tanks or cisterns quadrangular or rectangular in form or section; those applicable to tanks circular or round in section or form will be given in a future Note.

24. Dimensions of Plots or Parcels of Land to make up an Area of One Statute or Imperial Acre.

Width of Plot.			Length of Plot.			Width of Plot.			Length of Plot.		
Yards		Feet	Yards	ft.	in.	Yards.		Feet.	Yards	ft.	in.
3	or	15	968	0	0	34	or	102	142	1	1
10	„	30	484	0	0	36	„	108	134	1	4
12	„	36	403	1	0	38	„	114	127	1	2
15	„	45	322	0	0	40	„	120	121	0	0
18	„	54	268	2	8	42	„	126	115	0	0
20	„	60	242	0	0	44	„	132	110	0	0
22	„	66	220	0	0	46	„	138	105	0	8
24	„	72	201	2	0	48	„	144	103	2	6
26	„	78	186	0	6	50	„	150	96	2	5
28	„	84	172	2	7	52	„	156	98	0	8
30	„	90	161	1	0	54	„	162	89	1	11
32	„	96	151	0	0						

TECHNICAL NEWS.

Mileage of Railways.—A very striking statement was recently made by Mr. Webb, at the luncheon at Crewe by the Railway Company, to "The Iron and Steel Institute." He said: "It may interest some of the members of the Iron and Steel Institute to know that our mileage to-day is over 48,000,000 miles" (that is, more than half the distance of the sun from the earth). "Going into days, hours, and minutes, that means 131,520 miles a day, 5,480 miles per hour, 94 miles a minute, and 1½ miles every second of time. This, gentlemen, will represent a journey round the world about every four hours; and I am glad to say that our machinery is so perfect that we can go round the world an average of three times without losing either a split pin or a cotter." We have been accustomed to consider astronomy as the science of magnificent distances; henceforth we must admit that railway engineering has some claim to the title.

Electricity Packed for Removal.—Mr. Benger Spence and M. de Lalande have introduced a new method of electric lighting which promises great things, not only in the way of illumination, but as supplying a source of power in the most compact possible fashion. One writer, describing the new invention, says, "You may buy your electricity from the factory in a box, as you would tea, and you can use it without difficulty either for lighting or motive power." A 40-lb. battery will, we are told, drive a tricycle for a thousand miles at the rate of eight miles an hour; and the power can be turned off as easily as gas. Tricycling is already a very popular amusement, but it will be perfectly delightful if we can bowl along at a pleasant rate of speed, and without the tiring and certainly (in the case of ladies especially) ungraceful work with the treadles. Time will show, however, whether this dream is to be realised or not.

CORRESPONDENCE.

SIR,—I read in the newspapers a few days since the report of a conference of members of the Artisans' Technical Association with employers and workers in various trades. The Rev. H. Solly, long known as an earnest advocate of every effort to really improve the social and intellectual status of the working-man, said "that now the apprenticeship system was, in many instances, practically dead, it was necessary, if British industries were to hold their own against foreign competition, that young men under twenty-one should be compulsorily required to attend classes where they could learn the technology of their trades, the employers affording facilities for this purpose. Trades unions might aid the work by insisting that those who were admitted to their lodges should give proof of their knowledge of the technicalities of their trade." I, who have had some experience of workshop life, fear that our excellent friend is not quite so well informed as to the disposition of employers and members of trades unions as he might be. His suggestion reads well, but at present, at least, is not very likely, except in some very rare cases, to bear fruit. A vast number of employers take young boys into their workshops nominally as apprentices to learn the trade, but actually because boy labour is cheaper than man labour. The lad is kept close at work in one of the branches of the business, and passes his seven years in almost absolute ignorance of every other branch, unless his own will and intelligence induce him to keep his eyes open, and pick up here and there a bit of information. These boys are frequently paid, after the first year or so, on the piece-work system, at the rate of one-half or two-thirds of the standard of wages for men. Limited as the nature of their work is, they become fairly expert—that is, expert enough in the production of the "shoddy" work the master is content to produce; and at the end of their apprenticeship are turned out on the trade with the smallest possible amount of acquaintance with the handicraft they are supposed to have been taught—only able to do one thing—and other boys take their places. In my own case, I was presumably taught the business of a letter-press printer. There was something in my indenture of apprenticeship about "art and mystery," if I remember rightly. I was put to "case"—that is, picking up the types. In due time I was paid half the regular wages, then a little more. So long as I could hustle together a good number of lines—and I could soon do that—my employer was satisfied. What on earth did he care about my obtaining a fair knowledge of the various departments of a rather complex business? When my time was up, I was a tolerably good type-setter, but very little more. I knew nothing, for I was taught nothing, about press or machine work, the sizes and quality of paper, the composition and relative value of different kinds of ink, or a dozen other matters which a printer ought to be acquainted with. I have seen "young men from the country," and from London offices too, unable even to arrange the pages of type so that when printed the sheet would fold properly. (I avoid such technical terms as "imposition," which would, perhaps, not be understood by your readers who are not printers.) Many youths are set to work on newspapers, and pass seven years in setting up line after line, but know no more of bookwork or "jobbing"—that is, displaying bills and broadsides—than they do of Euclid's Elements. I am not here concerned with the question of trades unions, either for or against, and much can be said on both sides; but as I have frankly expressed myself as to employers in this matter of apprentices, I am somewhat inclined to believe that trades unions are as little disposed as employers to put themselves out of the way to advance technical skill. Whatever may be said to the contrary, the tendency to maintain a standard of mediocrity, to level down clever workmen, and to insist that the unintelligent, incompetent man shall be paid as much as the workman with brains in his head, is beyond all doubt antagonistic to all technical improvement and progress. And it does not matter to me by whom this tendency is created or maintained—whether by employer, employed, or the societies of the one or the other—its influence is only bad, and can be no other. In the course of the discussion it was freely admitted that "workmen were very largely ignorant of the principles which govern their respective trades." Ignorant they are likely to remain while the present system lasts. My conscience will not permit me to subscribe myself a "Printer." I am not quite sure that I could easily discriminate between a sheet of paper of the demy size and one of royal. Certainly if I were in business I could not buy and sell with judgment any of its materials or "stock." I know a printing machine by sight, but could no more work it than I could navigate a ship; yet I served an apprenticeship to the "art and mystery" of printing. As, however, I have set up many thousand lines of type, perhaps I may sign myself

ONCE A COMPOSITOR.

SIR,—I wish to express the pleasure I have experienced in perusing the first number of your Journal. Useful to all classes interested in "work" and how to do it, it will be especially useful to emigrants, who too often enter upon a new life strange in many of its aspects, with a most imperfect knowledge of the difficulties they will have to encounter—difficulties not always the result of external circumstances, but arising from their own deficiency in technical skill. The hopeful young emigrant thinks it an easy task to settle down in a new location, and make a home for himself and his belongings in the wilderness of Canada or Australia. "I shall run up a shanty," he says, "or perhaps a log hut. I have read a good deal about such places, and I think I can be jolly comfortable." He finds himself on the bush of Australia or on the borders of a Canadian forest, and then discovers that, though trees are plentiful, though he has a fair box of tools, and is strong and active, he has scarcely any idea whatever as to the way to set to work to construct his homestead. I have heard of one emigrant who wrote to the old country thanking the author of a book on building construction (which he had fortunately, perhaps I ought to say prudently, taken out with him) for the assistance it afforded, enabling him to dispense with hired labour, and which repaid the cost of the book—and it was not, as yours will be, a cheap one by any means—a hundredfold. The shanties and huts clumsily put together by some of the settlers in the locality tumbled down because the logs and planks could not hold together, or were blown down by the first high wind. The roofs were leaky, the wind whistled through innumerable crevices. Man and wife were wretched, the children ill, nothing prospered, because, with all the work in the world to make things comfortable, there was an unfortunate lack of a little elementary knowledge of the principles of construction. I therefore welcome the appearance of your Journal, which should be put into a corner of the emigrant's chest. If he brings intelligence to the task of studying the information given, not only may he have a comfortable, if rough, house to live in, but will know a good deal more about many things connected with live stock, crops, and similar matters, than he did when he first thought of setting out to seek his fortune in a colony.—I am, Sir, yours, etc.,

ONE WHO HAS LEARNED SOMETHING BY READING.

A correspondent writes us that the Schaffner & Helbig's process for Utilising Alkali Waste, referred to in Note No. 5 in "Technical Facts and Figures," has not proved a commercial success in this country. To some points of his obliging letter we may make future and further reference. In regard to this, the author of the above "note" has sent us the following:—"Your correspondent is, I think, a little in error in his statement that the above process has failed; thousands of tons of waste being yearly recovered with profit. Without doubt it has not quite reached the success hoped for when first introduced; but your correspondent should not forget that it takes some time to prove the success or failure of so extensive a manufacturing enterprise as the utilisation of so vast a mass of alkali waste as our large makers have to deal with. It generally takes some years of trial on an extensive scale—it often takes years of unremunerative working—before a process like this can safely be set aside as a failure. I have lately had a conversation with the heads of two of the largest English alkali works by the old process on the subject, and they agreed in this,—that as the process became perfected it could be profitably carried out by all Leblanc-ash makers. Both have laid out large amounts of capital in the improvement of the plant of the Leblanc process, and hope by so doing, and by subsequently working a modification of the above utilisation process, to compete successfully, although with greatly reduced profit to that made hitherto for the next ten or twelve years, with the ammonia-soda process. We are aware that one firm makes a handsome income by the recovery of sulphur from the waste-heaps which have been accumulating for years on their premises."

We may here add to the above, whilst the opportunity occurs, that when a commercial firm adopts a certain new or improved method or process the public are not always informed whether that method or process has been found to be successful on the large scale, and through all the exigences of practice. When a firm discards such method it does not always like to confess the failure—though generally no fault of its own. Again, when a process turns out to be successful—*i.e.* profitable—every business man well knows that it may not be to his interest to publish his success; not simply because it may give his competitors the benefit of his experience and capital, but for other reasons obvious to those who have technically commercial experience. As a rule firms do not like to confess to failures, and it may also be accepted as a rule that practical men of business care as little to tell of their successes. Continued exertion to make their work a success and to avoid failure is in truth much more in the way of business men than talk about either. And often success and failure are but relative terms. In fact, some of the most important of industrial improvements never reach the knowledge of the general public. It will form part of the plan of our work to place before our readers many improvements of this character derived from actual practice in several departments of technical industrial work.

ISSUE OR PUBLICATION OF PAPERS IN THE JOURNAL.—We have had several queries addressed to us with reference to the time at or the parts in which certain papers named in our General Plan of Work will be issued. With so varied and large a number of subjects which that plan embraces, it is somewhat difficult at the present stage of our publication—indeed, almost impossible—for us to arrange a scheme which will give a place or time to the issue of papers in anything like a consecutive or well-arranged order. We shall for the present be governed very much by circumstances in this matter—meanwhile, however, thinking over some plan by which the wishes of the majority of our correspondents may be met. At present we are able to give a definite answer to the question so courteously put by "E.M.," by stating that the first chapter of "The Land Drainer" will appear in next issue, that is, Part IV.

REFERENCE LISTS OF BOOKS FOR TECHNICAL STUDENTS.—With regard to this subject, we have had suggestions made to us that lists of works useful and calculated to be useful to technical students would form a very practical department of the Journal. This falls in so well with some notions of our own on the subject, that we contemplate having lists of reference works arranged under different sections of technical work prepared. While the different authors to whom those lists will be entrusted have a pretty wide knowledge of works treating on the respective subjects with which they are practically acquainted, they will, we are sure, feel obliged if any of our readers who may be disposed will send contributions to the lists. And in this way it may be here suggested that Publishers of technical works could aid the scheme by naming the works which issue from their presses. And this last sentence reminds us of the fact that several *Works sent for Review* are lying before us for notice. On this we have for the present only space to remark that it will be obvious that where there are such great demands made upon the space in each Part at our disposal, we have not much to spare for reviews of books. This much we may however say: that we are feeling our way to apportion a certain space for matter of this kind; and that if we can spare space at all for reference to any work sent us, we shall think it only fair in the interests of the publishers, and right in those of our readers, to give something more than a mere bald notice that the work has been received. In a case like this we shall endeavour to give our readers such a fair description of its general features as will be of some practical use to them.

PRIZE SCHEME OF THE TECHNICAL JOURNAL.

Notice to Intending Competitors.

IT has been represented to us that the time named in the first part for sending in the Designs and Papers connected with the various Prizes is too short, at all events in the case of the first of the Series. Taking into consideration the points suggested to us, and the in some respects novel characteristics of the Scheme generally, we believe that it will be alike in its interests and those of intending Competitors under it if longer time be granted than that originally announced. We have, therefore, to ask those of our readers who are preparing Designs and Papers to be kind enough to take a note of the fact that the date for sending them in under the various classes is advanced one month. Thus the date for

Class under letter A will be February 28th, 1885.
Class under letter G will be March 31st, 1885.
Class under letter H will be April 30th, 1885.

THE JOINER *(see Text).*

Panelled Door Casing and Architrave in Part Elevation and Plan (Figs. 1 and 2), with Details of Styles and Rails (Figs. 3 and 4), Raised Panel Work, Cross Sections (Figs. 5 and 6).

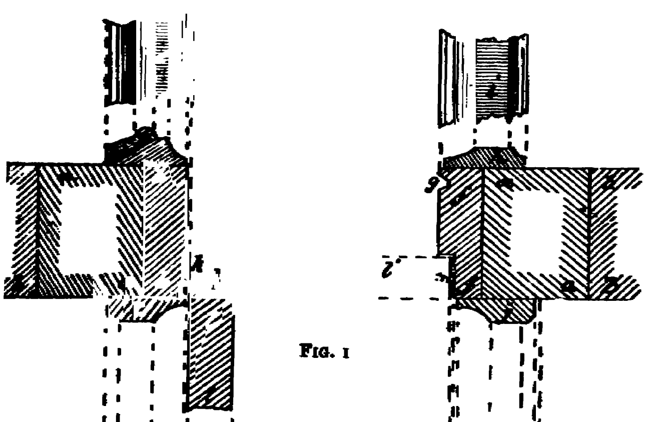


Fig. 1

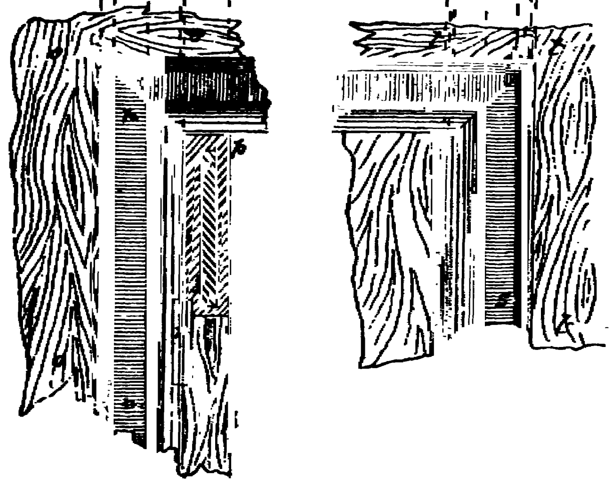


Fig. 2

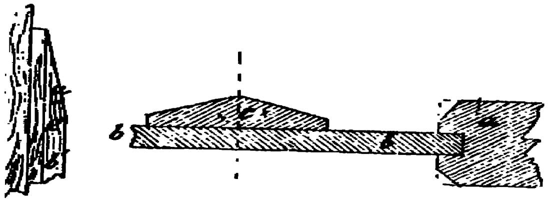


Fig. 5.

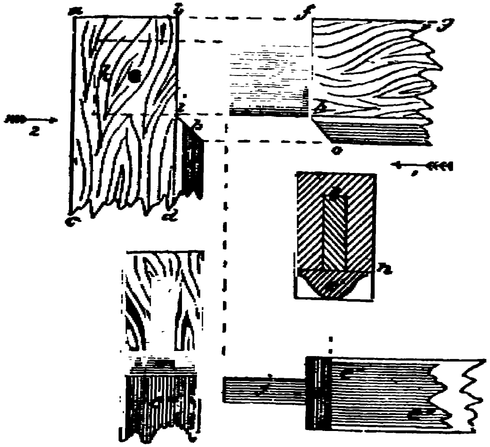


Fig. 3.

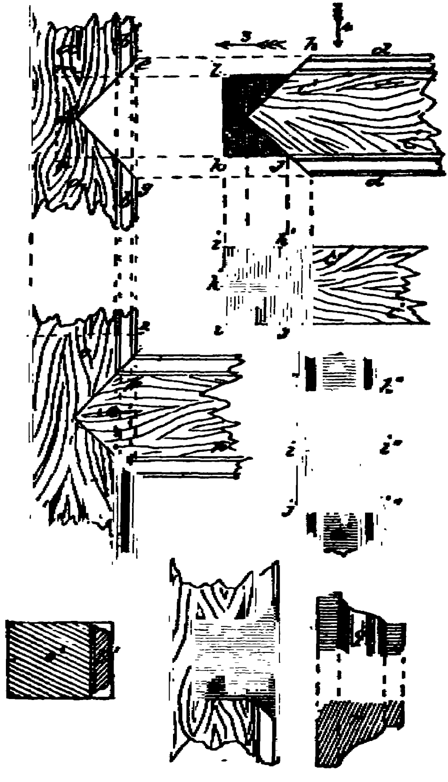


Fig. 4.

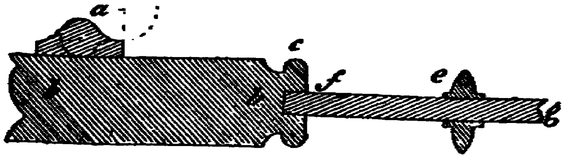


Fig. 6.

MOULDINGS—SCROLLS AND BANDS.

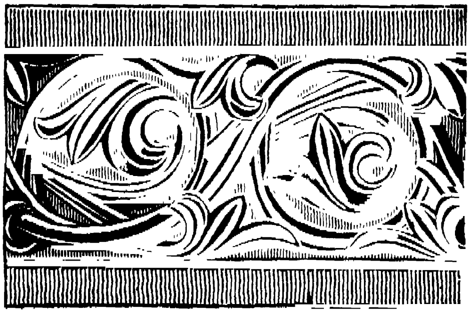
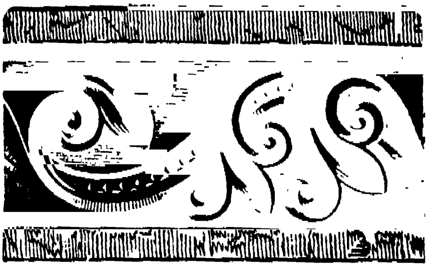


FIG. 1.



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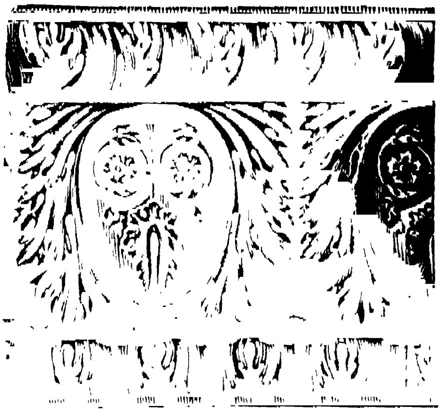

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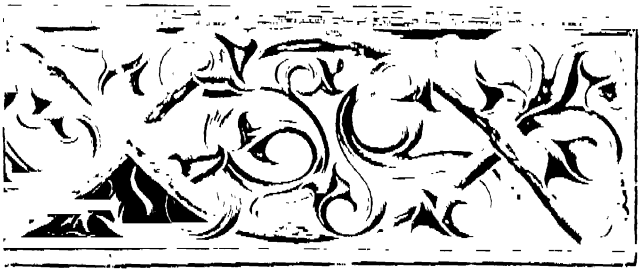


FIG. 4.

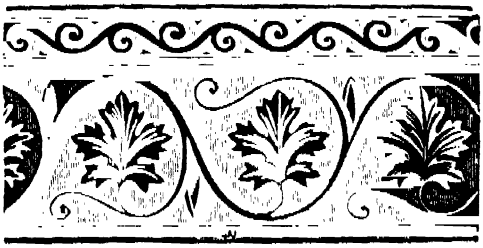


FIG. 5.

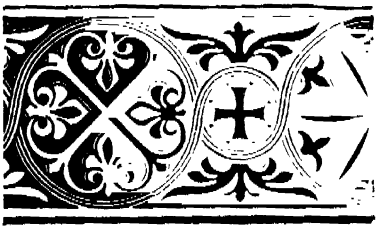


FIG. 6.

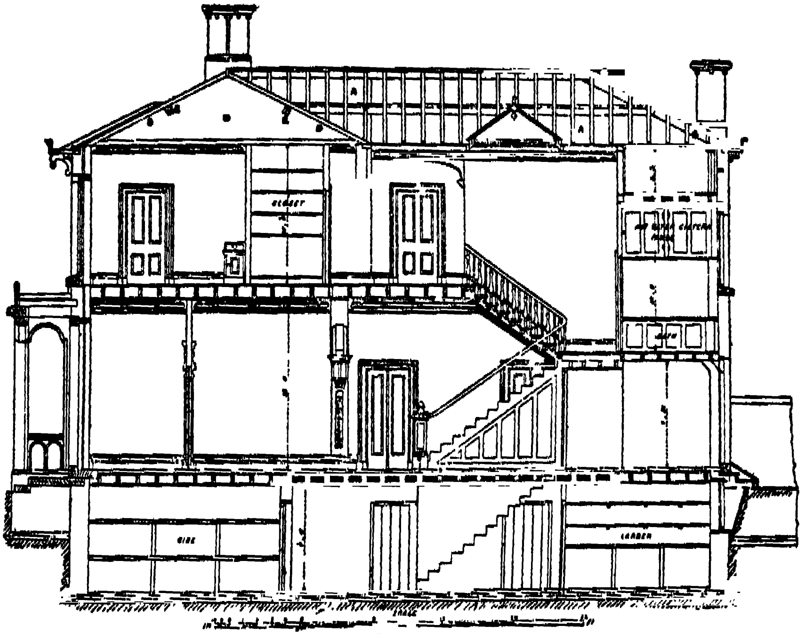


Fig. 1.

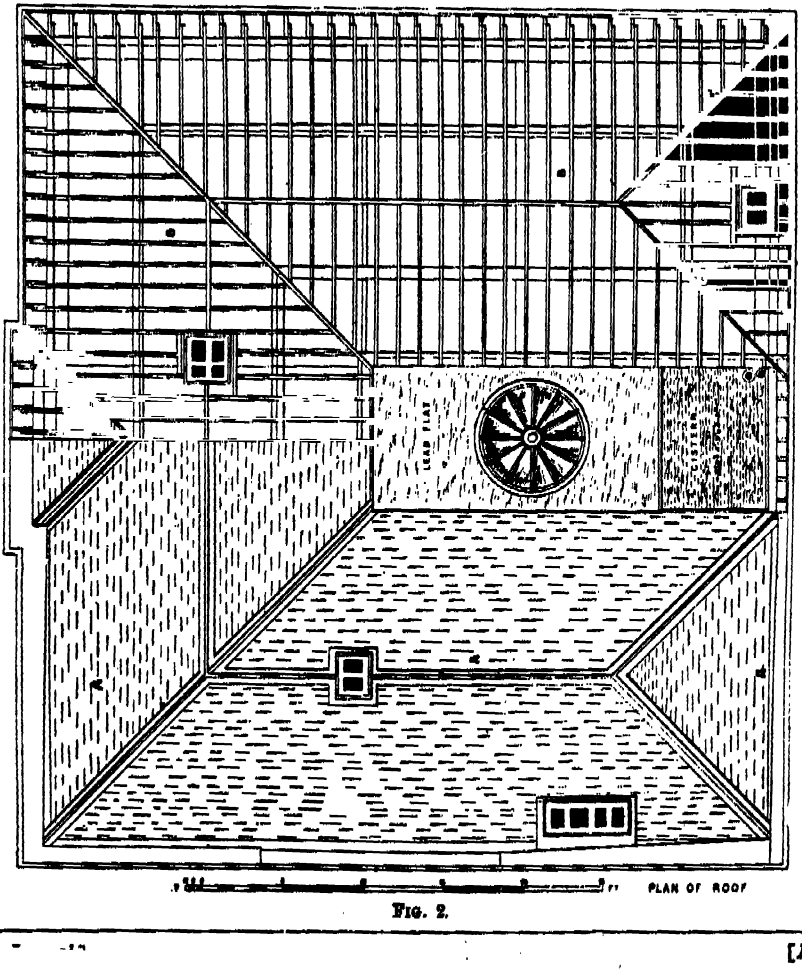


Fig. 2.

THE JOINER, THE CARPENTER, AND THE BRICKLAYER (see text).

ELEVATION AND PLAN AND DETAILS OF TWO-STORIED BAY WINDOW.

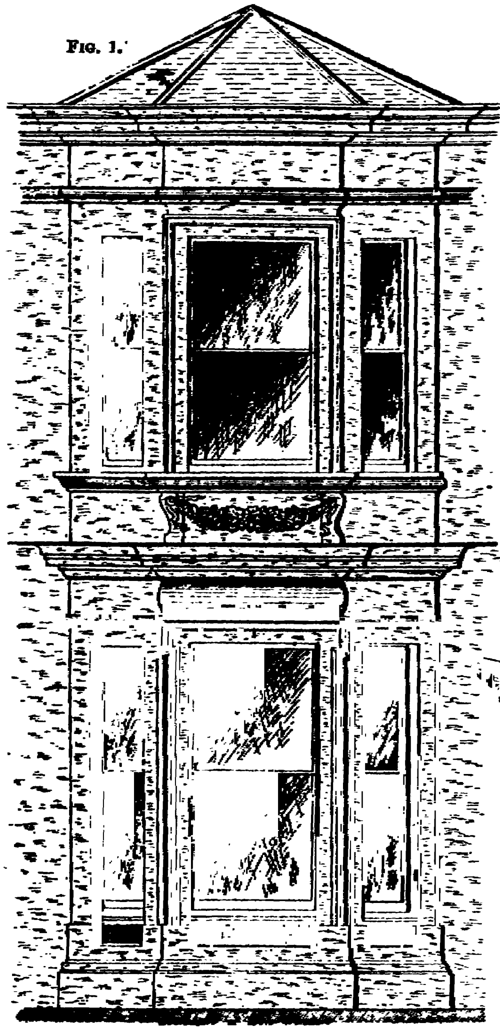


FIG. 1.

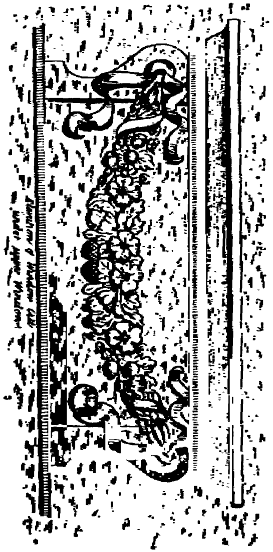


FIG. 2.

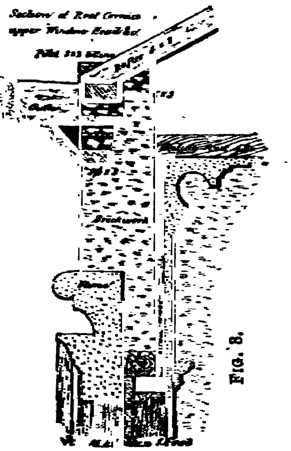


FIG. 3.

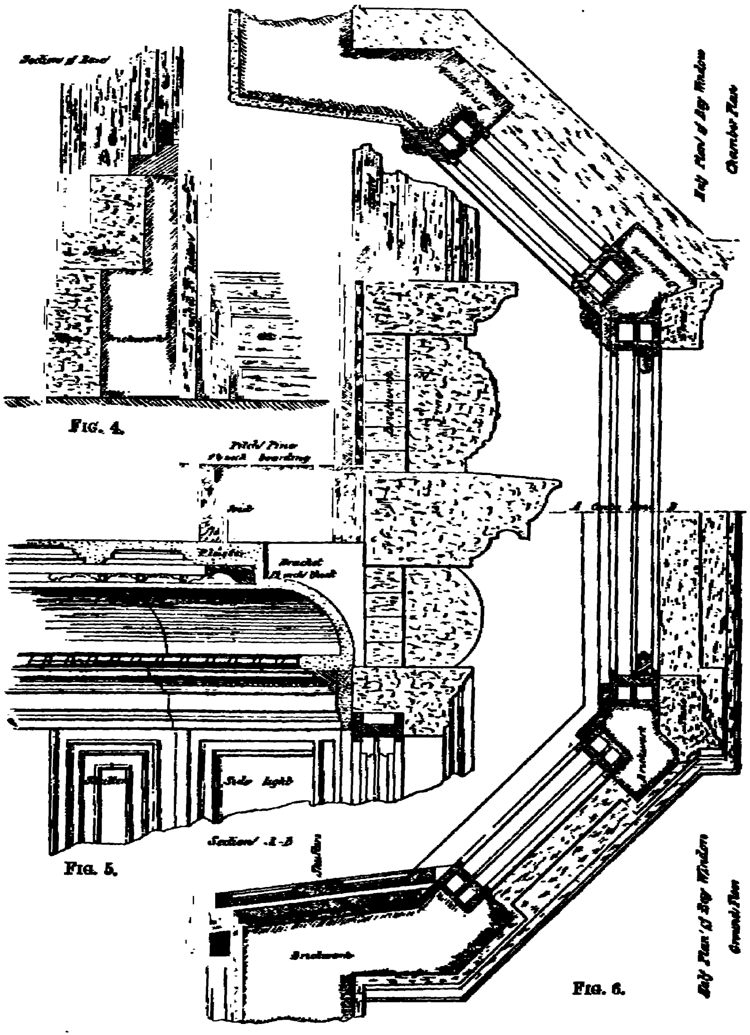


FIG. 4.

FIG. 5.

FIG. 6.

[Plate XXVIII.

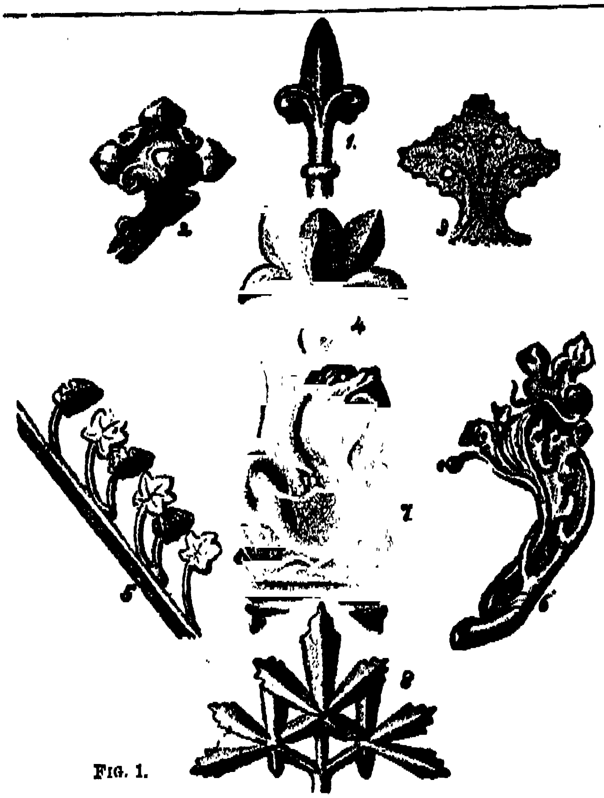


FIG. 1.

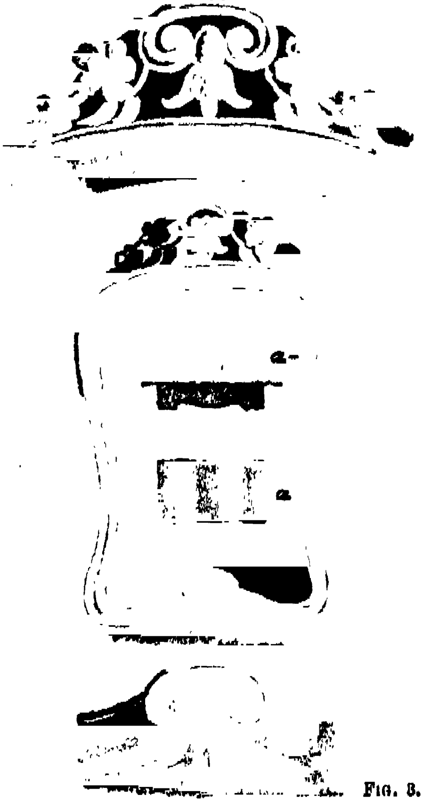


FIG. 3.

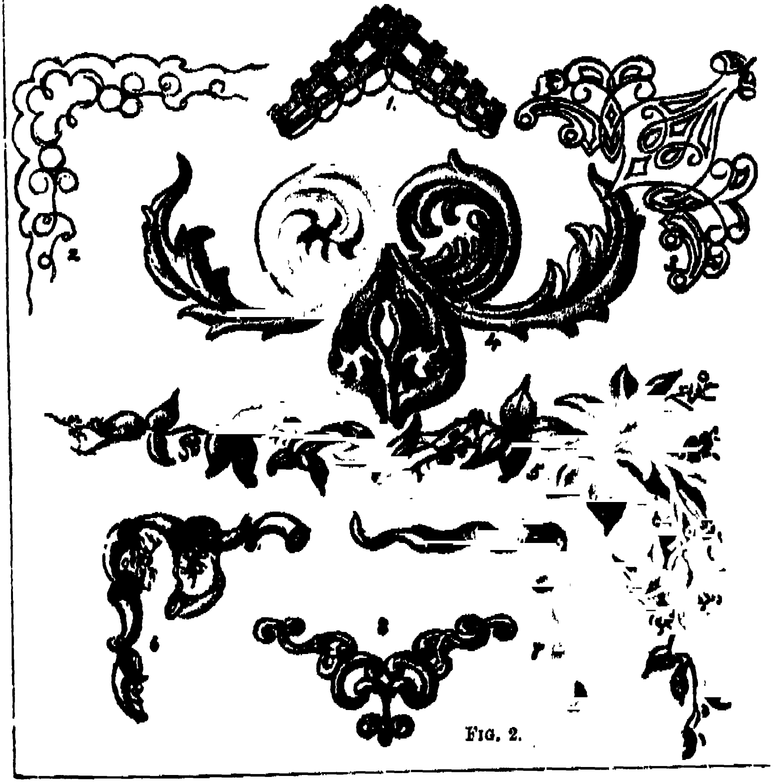


FIG. 2.

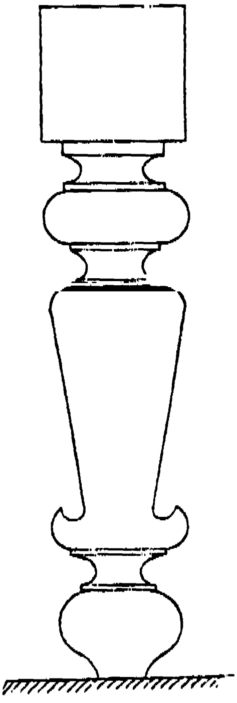


FIG. 4.

THE BRICKLAYER. (see Text).

ORNAMENTAL AND PERFORATED BRICKWORK.

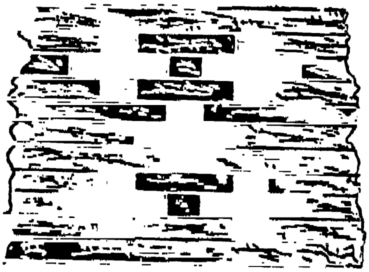
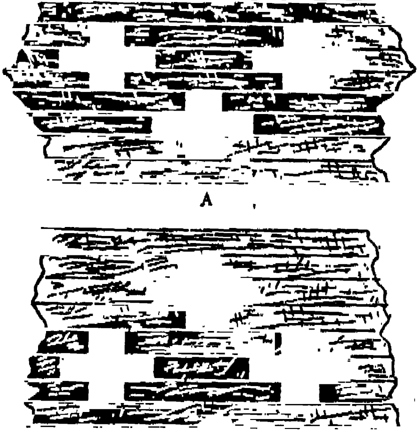


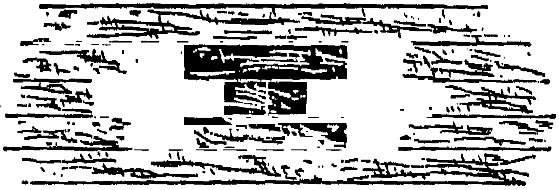
FIG. 1.



A

B

FIG. 3.



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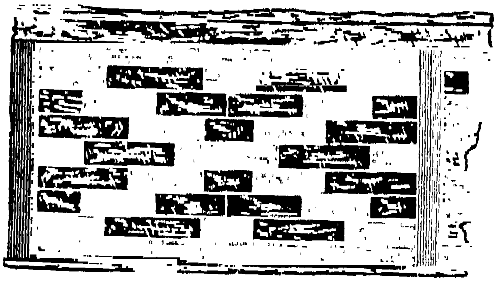

FIG. 4.

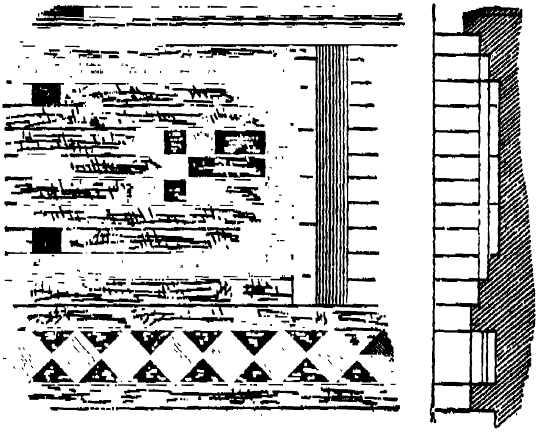

FIG. 5.

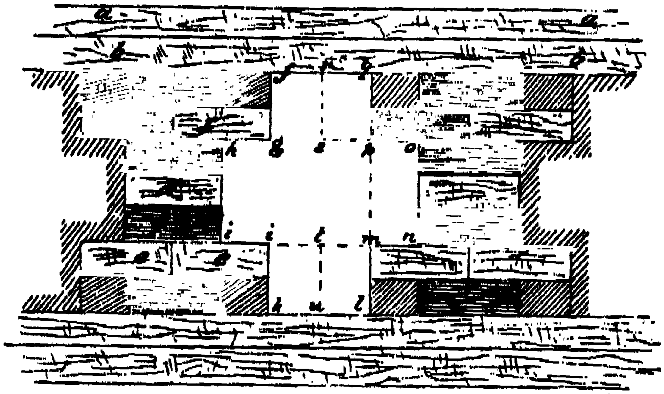

FIG. 6.

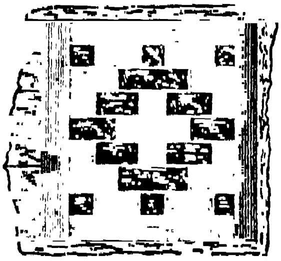

FIG. 7.

THE ORNAMENTAL WORKER IN METALS (see Text).

THE ELEMENTS OF ORNAMENTAL IRON-WORK.

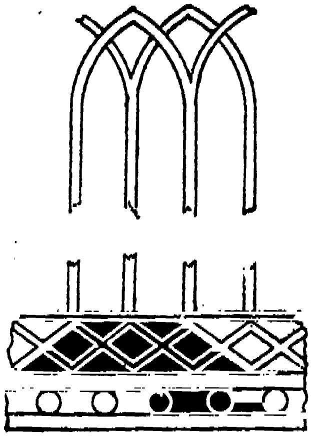
FIG. 1.

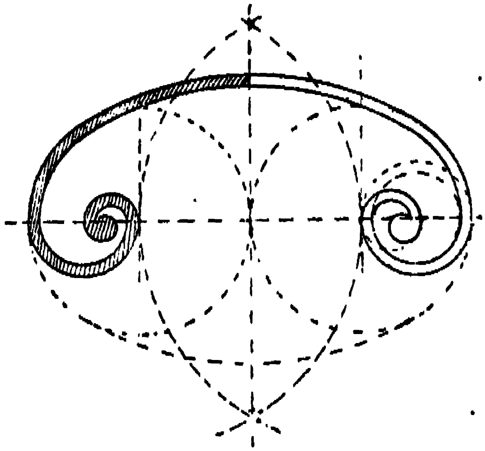
FIG. 2.

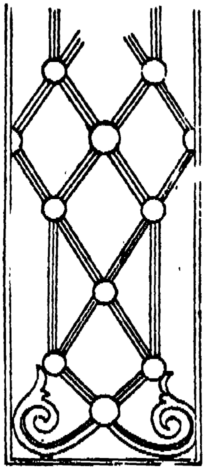
FIG. 3

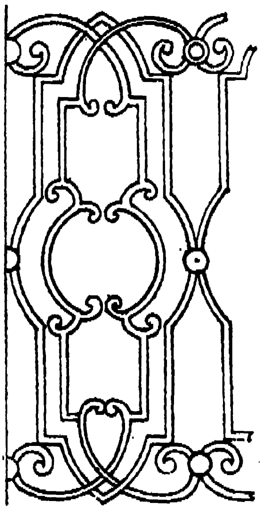
FIG. 4.

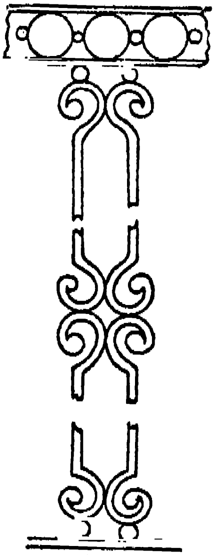
FIG. 5.

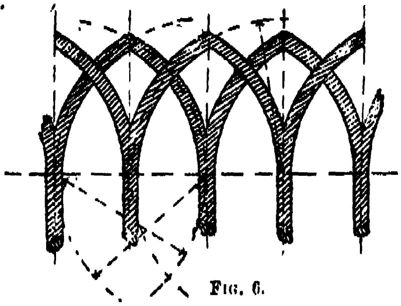
FIG. 6.

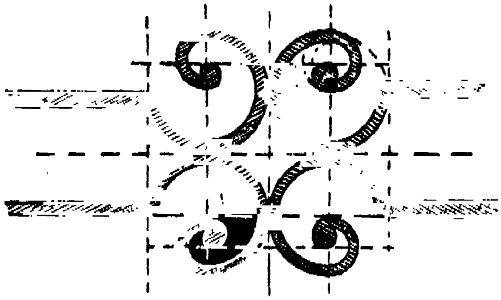
FIG. 7.

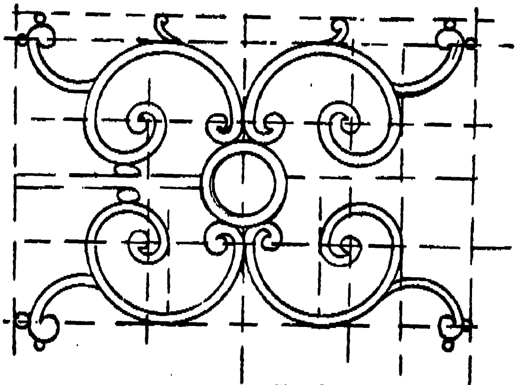
FIG. 8.

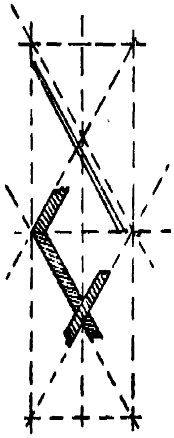
FIG. 9.

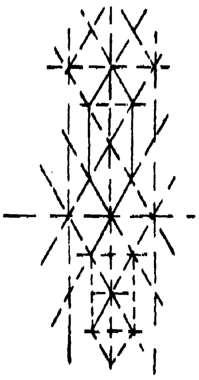
FIG. 10.

WALL OR PANEL DECORATION.

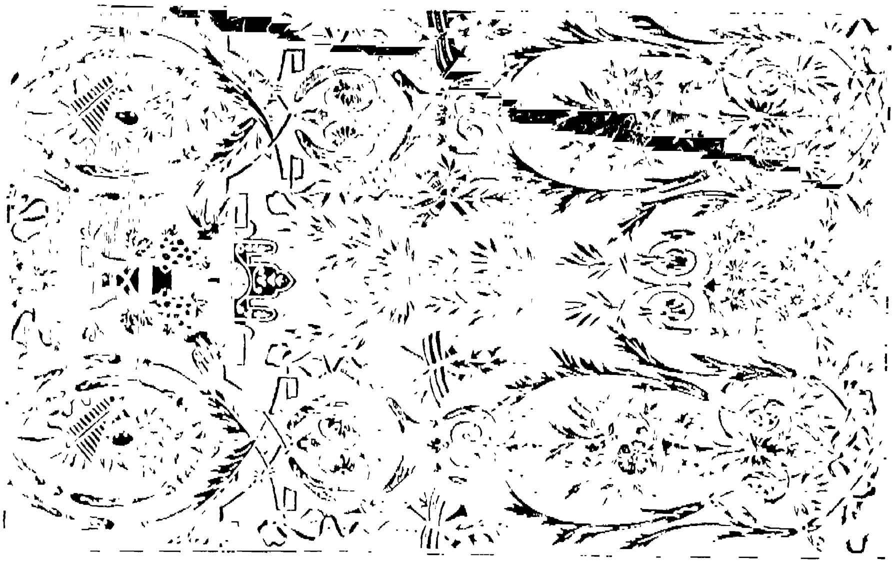

FIG. 1.

TEXTILE FABRIC, OR PAPER DECORATION.

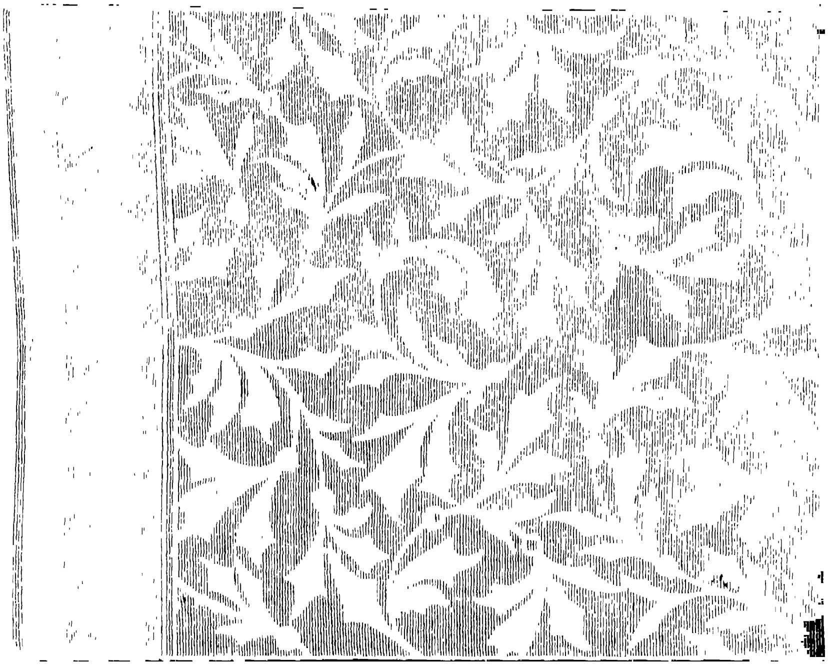

FIG. 2.

TECHNICAL EDUCATION

IN RELATION TO

THE PRESENT CONDITION OF OUR INDUSTRIAL WORK.

CONTENTS.

The Circumstances of the Working Classes, their Working Hours and Leisure Time as Influencing the Wide Extension of Technical Education—Importance of Individual Study—Technical Education at the Home—Books the Important Element in the Technical Education of the Home—Difficulties which some Technical Scholars—as those of a Retiring and Slow Disposition—have to contend with in the Public Class or School—The Teaching of the Class, or *Vivâ-voce* Instruction, Absolutely Necessary, however, in some Departments of Technical Knowledge—Other Difficulties in the Way of speedily securing a General Extension of Technical Education through the Medium of Public Classes: the Teachers; the Competitive System—Some Valuable Characteristics of the System of Home Technical Education—The Essential Characteristics of Books fitted for the Technical Education of the Home—The Claims which the Present Work has to be considered a Complete, Comprehensive, and Trustworthy Text-book of Practical Value to the Technical Student.

The Circumstances of the Working Classes, their Working Hours and Leisure Time as Influencing the Wide Extension of Technical Education.

In addition to the reasons previously named for believing that it will be long before our public institutions can possibly be established in number and in efficiency calculated to overtake the work before them, there is this other reason which must be taken into consideration. That even when more widely established than they now are, they cannot possibly absorb or draw within their influence all our industrial workers. For be it remembered that the element of "leisure time" must be taken into account. It is an easy matter for those who have nothing else to do than to be educated to attend technical schools and institutes—comparatively easy for many who are employed in certain callings which, while they cannot be classed as handicrafts, are yet in some respects industrial or technical. It is, however, not so easy a matter for the great majority of those who do the actual work of our great industries. They have to work to live, and live to work. This, in fact, constitutes one of the real practical difficulties in the way of establishing a public system of technical education which will take in or absorb within its practical work the very classes which it is designed to benefit. They have not the time, neither have they always the physical vigour and activity, after a hard day's work, to begin to them the still harder work of walking to a school—probably very distant—and thereafter to begin to study, which is to them harder still. If one may venture on an expression which, however unusual, conveys a vast deal of practical truth bearing on the whole subject of technical teaching, many of our working classes have to be taught not only the value of being taught, but how to be taught—*how* to learn that which is capable of being learned.

Importance of Individual Study.—Technical Education at the Home.

These are facts, and, like all facts, must be dealt with in a practical way. *Individual* study must therefore for long—indeed, it will be always—an essential thing to be gone through. The public school can and will do much—it cannot possibly do all. And beyond a doubt it will not always be adapted to the circumstances of our industrial workers. It remains to be seen whether by the light of future and further experience this adaptation will be secured in a thoroughly efficient way. It is not, at the present stage of our national progress in public technical education, anything derogatory to such systems as have been established to say that they have not as yet met the requirements of this adaptation to the circumstances of working men of all classes in anything like an efficient way. As we have said, all such measures as we have taken in this direction are as yet but purely tentative or experimental. We have therefore, as a consequence of this position, to get rid of many defects which they have carried with them—defects readily enough acknowledged by those who are the most practically connected with their working.

But valuable as schools, classes and institutes may, and as they will yet, be made, they never can do away with, or themselves succeed indeed without, the influence of Home Study. This, under the present circumstances of the working classes, is an absolute necessity. And such or similar circumstances are in all probability destined to be attached to those classes in times to come.

Even where the public school is attended, unless its work be supplemented by the study of what may be called the school of the home, that work will only be of indifferent value. But, in a large number of instances, the technical class or institute will not be available. It is only in large towns that we can, at least for a long time to come, hope to have such public facilities for imparting technical education established. And even in such populous places—and markedly in those which spread over large areas, such as the metropolis—the mere distances to be travelled by students from their homes to the public school or institute will prevent a large number from making use of them. And so far as the system which has been proposed by some of grafting upon our ordinary school-teaching methods for imparting special technical instruction is concerned, we have still less hope that we shall see this speedily carried out. And this, not so much merely from the difficulty of combining the two, as from the still greater difficulty of obtaining the services of the obviously great number of teachers required in such an extensive system of school-teaching,—teachers who, to be of any practical use, must be well qualified to fulfil their duties. Even now, when our technical institutes and classes are but very few in number, the difficulty to find competent teachers is very great,—so great, indeed, that one of the most important works of the future will be the "teaching of teachers," in order to supply the great and ever-increasing demand for men capable of teaching others. Much, therefore, as will be done by public classes, more must be done by private study in the home. There are those, indeed, who believe that the highest service which the public technical institutes can render, will be in directing the attention of students to books of practical value, in great measure inciting them to a close and earnest study of those; and not only so, but in encouraging close habits of observation, and *vivâ-voce* intercourse with their fellow-workers. Those combined influences are, as we have said, by many high authorities in technical education believed to do actually more in imparting practical knowledge than even the most persistent and patient attendance upon the technical class or the lecture-room.

Books the Important Element in the Technical Education of the Home.

Books, then, must ever play an important part in the great work of technical education, and this even when the public class or the institute is relied upon chiefly as the method of imparting instruction. For in this latter case text-books are required to aid and supplement the labours of the teacher;

although if he is a peculiarly able man his pupils will be somewhat tempted to neglect their text-books in reliance chiefly upon his *vivâ-voce* or spoken statements. But if text-books or guides to knowledge of different kinds play, or are apt to play, but a secondary part in the practical work of the public class or institute, they hold the first position in the Technical Education of the Home. Here they are simply and absolutely indispensable. Playing a double part, they take the place at once of the teacher of the public class or institute, with his *vivâ-voce* statements and explanations, and the text-book by which those are aided, influenced, and supplemented. And although we are or should be the last to lower the value of the living teacher in the estimation of our readers—for his services are of priceless worth to the nation—still it will be readily enough admitted, on due consideration of all the points involved, that the book in the study of the home possesses advantages to which but few teachers in actual practice can lay claim. The teachers can only be met with at stated hours and at comparatively long intervals. And in the unavoidable pressure of class-work, with all its inevitable concomitants of differences in the peculiarities, the idiosyncracies of different pupils; the many questions to be answered, the doubts resolved, the difficulties to be removed; it not seldom happens that there is more work of education to be done than there is time given for the doing of it. Nor is the case altogether unknown, —some, doubtless, will aver, and with much truth, that it is on the contrary but too well known,—where the pupil is shy and reserved, and afraid to ask questions the replies to which it is necessary that he should have, but with which unsolved he has to leave the class-room. None the less known, perhaps, but unfortunately too frequently passed over as a matter of no moment, is that case in which the pupil belongs to the class popularly described as those who are "slow in the uptake," or who have a difficulty to conceive quickly the meaning and purpose of what their teachers tell them; although if time were given them they have that peculiar gift, so valuable to technical men, of firmly grasping a practical fact or a scientific truth which they do clearly understand, so that it becomes then their mental property for all time. What they have thus time to secure, they never lose; but unfortunately, in the unavoidable pressure of the teaching of the class-room, that time cannot always be given—in plain truth, is sometimes not given at all.

Difficulties which some Technical Scholars—as those of a Retiring and Slow Disposition—have to contend with in the Public Class or School.

Hence, in the public teaching of the class or the institute, it often happens—and so frequently, indeed, that some aver it is the rule—that it is only the forward and the highly-favoured in intellectual gifts, especially in that gift of quick reception of facts and principles, who are the marked and fortunately successful pupils. But there are the others, to whom we have just alluded, none the less truly gifted, who have all the capabilities intellectually of becoming able students, but who, unfortunately for themselves, are somewhat slow in conception, or shy, reserved, and bashful in manner. But with the book in the study of the home all those disadvantages disappear. The student slow in the perception of scientific truths, in the comprehension of the precise value of practical details, but possessed of a mind which retains firmly what he does finally understand, can go again and again to his book, and remain with it as long as he desires, without any fear of being troublesome to his teacher, or of being put off with a brief explanation or a hurried, in some instances a gruff, reply. Nor need the bashful and the reserved—those who in actual intercourse with their fellow-men, and especially with their teachers and superiors, require to be brought, who never of themselves come forward —be afraid with their book. That is ever ready at their wish, —patiently waits, so to say, the time when the truths it enumerates, the facts its pages give, shall be duly and fully understood and appreciated even by minds the slowest in comprehension.

The Teaching of the Class, or Vivâ-voce Instruction, Absolutely Necessary, however, in some Departments of Technical Knowledge.

We give these remarks as to some peculiar features of *vivâ-voce* teaching, or what is called the oral instruction of the teacher, inasmuch as they exercise an influence more potent than many think of, in the working out of a practical system of Technical and Industrial Education, and which must therefore be taken into account, otherwise grave mistakes will be made, and much disappointment as to results will arise. But do not let us be misunderstood as to our reason for offering these remarks at this stage of our inquiry. We offer them because they refer to facts; and facts of daily life must be met and fairly dealt with. But while drawing attention to them as factors of importance in all calculations as to educational work in technics and industries, no one will for a moment suppose that we are disposed to underestimate the value of the living teacher's work even in the slightest; still less to hint that this can be ignored in any system of Technical and Industrial Education. For while, in some cases, the aid of the living teacher, or the help of *vivâ-voce* lessons, can be dispensed with, and its place taken by books much more efficiently; nevertheless there is a wide class of technical and industrial educational work in which books cannot possibly impart the desired information or give the necessary knowledge which will be practically useful. To those acquainted with technical or science teaching numerous examples of this will at once occur to the mind. The one or two which alone our space will permit us to give will suffice to illustrate this point. Take Technical Chemistry. While the leading principles of the science can be gathered from book study, aided by such home experiments as may be within the command of the student, there are some points, and they are all of the highest practical value, which cannot be learned without the direct intervention of the living teacher. In analysing substances, for example, certain stages of the processes will be marked by certain physical phenomena,—such, for example, as on the emission from the substances under analysis of certain odours, perfumes, or smells, and the display of certain colours, etc. Hence in a wide variety of instances the student in Technical Chemistry has to become acquainted with certain odours, shades of colour, and the physical peculiarities of an extensive range of substances, as solids, liquids and gases. Now, all this has to be shown him by a teacher who himself thoroughly knows all, even the finer or the finest shades of difference displayed under different conditions of substances, and who is able to direct the student and to tell him when he makes a mistake and draws a false inference as to the presence or absence of a certain substance, from the indications it may offer to his notice. In no department of technical instruction, indeed, is the value, the absolutely indispensable necessity of the living teacher and the *vivâ-voce* lessons, more closely and clearly exemplified than in Technical Chemistry,—it being almost literally true that the teacher has to be constantly with the student, watching his work, noting his progress, warning him as to mistakes likely to be made, showing him how these can be avoided, and pointing out the thousand-and-one things necessary to be known. This at all events is absolutely true of what is *par excellence* the practical work of the technical chemist—the practice of the laboratory in analysing substances qualitatively or quantitatively.

This essentially necessary help which the technical student can receive only from *vivâ-voce* lessons—in other words, by the direct agency of the teacher—is also required, although not in all or indeed in many cases, in other departments of study. For example, in the work of the ornamental draughtsman and colourist, and in many departments of industrial work, where a student can be *shown* how to do a thing, and may be made to understand why it is so done, and this at once, which a laboured written or printed description, or even a lecture paragraph, would have failed to convey. There are some technical points, some technical operations or constructions, as in drawing and design, which no written description could possibly make clear without the eye being called in to the aid of the mind. Hence the value of illustrations on the blackboard of the lecturer, and of diagrams and drawings in the book. Hence also, in the case of materials and substances used in the technical arts and industries, the value of specimens—and as a consequence of museums, etc., where those specimens and models, drawings, etc., can be met with—by which the mind is enabled to grasp their peculiarities and characteristics with a clearness and distinctness which no written or even *vivâ-voce* explanation would yield.

Other Difficulties in the Way of speedily securing a General Extension of Technical Education through the Medium of Public Classes: the Teachers; the Competitive System.

All these points show how many-sided a subject Technical and Industrial Education is, and the difficulties which stand in the way of its being established nationally, so as to be thoroughly and practically useful. And so far as teaching by *vivâ-voce* lessons is concerned, seeing how in so many directions it has to be carried out in the closest of ways before it is practically efficient, the difficulties in the way of getting a body of men large enough as regards numbers and highly trained enough as regards practical efficiency, are such that it will be, if not a very long, at least a considerable time before such difficulties can be overcome. But it is not merely the difficulty, which is much greater than is generally supposed, in getting teachers numerous enough,—possibly a greater difficulty will in future be found to be in getting them possessed of the gifts which enable them to communicate the knowledge they themselves possess to the students placed under their care. This gift is altogether different and apart from their abilities as teachers *per se*—that is, their training in knowledge. This may be of the highest character, and yet from lack of the gift they are not able to give to others what they themselves possess. Like the poet, it may be said that the teacher is born, not made. No amount of acquired knowledge will give this capability to impart it to others. And even when obtained and acquired, the difficulties in the way of getting the teachers and students in that direct and peculiar mental connection which alone makes *vivâ-voce* teaching thoroughly valuable, is such as cannot in any wise system of National Technical Education be ignored with safety, as they will not in practice be overcome with anything like ease or quickness. And it is just those difficulties which affect another department of *vivâ-voce* teaching—namely, competitions and examinations—and so affect them that before they are thoroughly useful they will have in their main features to be materially modified from what they are now. On all these points, so far as the personal relationship of students is concerned, the reader careful to go thoroughly into the whole question of Technical Education may be referred to a paper in the text of this work given under the head of "The Workman as a Technical Student—How to Study and What to Study."

Some Valuable Characteristics of the System of Home Technical Education.

Taking a fair and impartial review of all the circumstances of the present position of the question of Technical Education, it is abundantly evident that for a long time to come, Home Study *will* be the chief source of that improvement in the capabilities of our technical and industrial workers, for work which every one is now convinced it is an absolute necessity for us nationally to obtain. And this is altogether apart from any questions connected with the merits or demerits of the home study system as compared with that of class teaching. And this simply from the fact to which we have alluded—that from the difficulties, in many districts and under many circumstances of industrial workers insuperable, in the way of getting efficient class teaching quickly and fully, they are thrown back upon home study as the only source of improvement available to them. But those thus thrown back upon this system have much of an exceedingly satisfactory nature connected with it to encourage them in its earnest pursuit. For in addition to what has been already said, and what may yet be given in special papers in the text, as to the advantages presented by home study, the following may be perhaps encouraging. Those who have had a wide and practical experience of the men who are occupied in technical and industrial work, and of the character of that work, have not seldom had occasion to observe that those workmen engaged in technical work who were attentive students at home occupied in technical knowledge a much higher place as students who knew—that is, naturally possessed scientific knowledge—than many who had had the advantages of a highly organised and more or less expensive public college or class training.

We have said much—and it was necessary to be given—as to the difficulties attendant upon the establishment of a general system of public technical education, which will be so wide in its development that it will take in all the classes engaged in technical industry, and so well fitted for the field which it should occupy that it will meet the varied and often varying circumstances of their actual daily life and work. And what we have said is perhaps the best evidence which can be given in favour of the vast value of the technical education of the home, in which the book is as wholly indispensable, as it is the principal practical feature. Everything of course depends, in this style of study, upon the character and class of book which is to be adopted as the guide to or text-book for the home student. For there are books *and* books.

The Essential Characteristics of Books fitted for the Technical Education of the Home.

The indispensable feature of a book which offers itself as a guide to the home student is that it shall be trustworthy—in other words, that its information be correct. Scarcely less important is it that it shall give this information in a way which will attract rather than repel. A guide may know the country well through which he proposes to lead a traveller; but he may be so rude and rough a companion, may give his information in such a way, may reply to questions so bluntly and brusquely, that the traveller would rather forego all the advantages attendant upon following the route proposed than take it along with such a guide. And if this would be so in the case of one who was thoroughly convinced of the advantages to be gained by traversing a district, much more easily would one be repelled by the manner of his guide from following his direction or entrusting himself to his care, who was not quite sure as to the advantages of going over the route at all. And so with technical text-books purporting to be guides to the home student. For it should not here be overlooked that with a vast number of those engaged in the actual work of technical industry, there is but little real conviction of the high value which so much scientific knowledge possesses when applied to the improvement of its various branches. Many, in fact, have to be incited to learn, and encouraged in every way in the actual acquirement of facts and principles. A text-book should therefore be written in such a way that, while its information is perfectly trustworthy, it shall be so attractive that it will lead the readers of its pages almost insensibly, yet powerfully, forward. It should, moreover, be so suggestive in its style that it will compel them to think—make thinking, indeed, a pleasure rather than a pain, as it is, in fact, with but too many of our workers, The text-book or guide for the student at home, while thus presenting certain features which are in fact indispensable, will mainly be the vehicle of conveying the results of the experience and the practical knowledge of its writers in the various departments which its pages discuss.

But, much as may be embalmed in a special text-book, and in books generally which treat of technical subjects, there remains a vast amount of practical detail floating, so to say, about, which has as yet found no abiding place in literature. Much of this is being gathered in, and place given to it in one published form or another. But this collection or gathering in is nevertheless being done in such a planless, desultory manner, that, highly valuable as the information is, it is so far from being readily available, that those who might be supposed to know almost everything on the subject of technical knowledge, know only that such and such information has been published in some stray paper or another, but do not know how to lay their hands on the vehicles in which it appears. If such be the case with those who may be called "experts" in technical literature, what chances have the great majority of technical workers of gaining access to this wide and usually full supply of that technical knowledge on which we have shown that the future value of their work and the future fortune of their trades depend?

And if the difficulty of gaining access to a treasure-house like this of practical facts exists in the case of such an infinite variety of publications in our own familiar language, what must it be in regard to the same class of knowledge hidden in the no less varied sources of foreign languages? There is a chance, though but the poorest, of obtaining, in some way more or less difficult, and at some time more or less remote, the information from such sources as we have named, which have been already published in our own language. There is scarcely any chance, however,—we might well say practically none,—of getting hold of the like information which is at present almost wholly embalmed in foreign languages—in books, papers, and pamphlets, which are in themselves but as "sealed books" to the great majority of our people.

The Claims which the Present Work has to be considered a Complete, Comprehensive, and Trustworthy Text-Book of Practical Value to the Technical Student.

A book, then, which would bring together in an easily accessible and cheap form all the combined results of the best thinkers about, and the most able and skilful of workers in all branches of, technical work, would simply be invaluable, as the soundest and the best of instructors. But if to all this were added the very latest results of scientific investigation and the most recent and pecuniarily valuable labour of our workers in our own country, and from the districts most celebrated for their production in special branches, together with the most valuable portions of that wide variety of technical knowledge floating about in this country and in other countries to which we have already pointedly alluded; and if the whole were arranged in a methodical manner, were illustrated by diagrams, plans, sections, and elevations,—in brief, by working drawings and readily available sketches and diagrams, —some idea may be formed of the practical value which a book of this kind would possess to our technical workers throughout the kingdom.

Such a book, we have reason to believe, will be that to which this is the General Introduction; and we now invite the attention of the reader to some of its leading features. To make it complete in the fullest sense of the term, within the reach of earnest endeavour, is the intention of its conductors. To do this no effort has been or will yet be spared. Its plan or method has been the subject of long and anxious thought; and to carry this out in all its details the best authorities in this country, as well as in America and on the Continent, have been consulted, and the help of the most practical authorities and writers secured.

A word or two as to the practical value of the technical literature of the Continent, which is one of the outcomes or results of the system of Technical Education which has been so long carried on there, will be useful in this connection. This literature does not exist mainly in the form of text-books for schools and students, although those are as excellent as they are numerous and complete. It embraces also a vast body of information on technical subjects, which has found place in special reports and volumes issued under government sanction, and paid for out of national funds. For Continental governments have, with a wise prevision of the necessities of national industry, deemed it their duty to foster and encourage all classes of practical work, by the issue of a wide variety of papers, books, and documents, connected with them. Nor less marked in practical value is the technical literature which owes its existence to the skill, the knowledge, and the remarkable trade enterprise of publishers. To those amongst us who for the first time come into direct contact with what may be called the full stream of Continental technical literature, embracing all the three great branches we have named above, the first feeling is one of gratified surprise that so much has been done for the people in the way of placing within their reach such a vast body of information bearing in the most direct and practical manner upon those branches of industrial work upon which depend in great measure their well-being and prosperity as a people. But to those who are intimately acquainted with the subject, it is impossible to be otherwise than matter of great regret, that *our* technical literature, considered from a national point of view, should present such a marked contrast, both in extent and character, to this Continental literature. One marked feature which it presents is the profusion of illustrations which is displayed in the great majority of the works, and the extreme beauty with which in most cases these illustrations are executed.

From a long and intimate acquaintance with Continental technical literature, the conductors of the present work are fully alive to the value of the rich store of information to be had from its numerous works. From extensive sources, covering the whole field of technical work and industrial processes, they have therefore made a careful selection of material. This, when printed under new arrangements specially adapted to the pages of a work intended for circulation throughout not merely all the districts of our own country, but in all places throughout the world where the English language is spoken and English skill, energy, and enterprise is displayed, cannot fail but to add immensely to its practical value to its readers. From various Continental sources, moreover, the conductors have also obtained a large number of beautiful illustrations, which will add to the attractiveness, as well as to the practical utility, of the work. Such is one of its features, to which special attention is here drawn.

THE CARPENTER AND HIS TECHNICAL WORK.

Its Origin and Early Progress—The Principles and Details of its Practice.

CHAPTER III.

The Method of Dealing with Timber, Trees or Parts of Trees, in the Early Constructions of the Carpenter, continued.

As construction improved, the value of flat surfaces would be seen, if in nothing else than in the closer joint which could be secured than by the use of round timbers, which could only touch at one point in the circumference, leaving rounded or hollow surfaces on each side. This we roughly illustrate in fig. 17, in which *a a* shows the good joint formed by two flat-surfaced pieces of timber lying together. It is a narrow point only at which the two round branches *c*, *d*, can touch, leaving the hollow spaces *e*, *e*, on each side. The inequality of the joint is, however, still more clearly shown in looking at the sides or along the length of the branches, as at *f f* and *g g*. Branches are often very crooked, and it would not be an easy matter to find two branches so well matched that the hollow in the under side of a branch, as at *h*, could be filled exactly up with the rising or swelling part of another, as at *i*. Much more frequently would the case be as at *f f* and *g g*, where hollow places—which would form holes—would be formed, as at *j*, *k*. The infinitely better joint obtained by using two flat edged pieces straight in the direction of their length is illustrated at *l*.

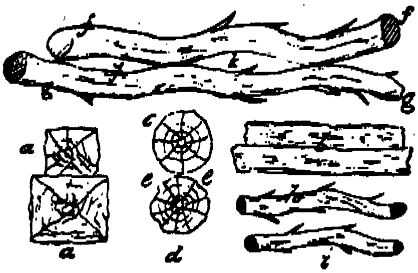

Fig. 17.

The splitting of round timber, or of a branch, as *a* in fig. 2 (*ante*), in two—in which operations the value of the "wedge," as at *b*, driven by the "mallet" or hammer, would be early ascertained—in the direction of its length, would obviously give two flat surfaces, one to each half. as at *c c* and *d d*, fig. 18. By using the axe, the adze, or the chisel, the rounded side of the half-branch, as at *a* in fig. 3 (*ante*), would be made flat also, and the first "plank," as at *b*, would thus be formed. Its breadth would be determined by the diameter of the branch out of which it was cut; its thickness by the extent to which the rounded side would be flattened down. The plank so formed would naturally have its upper surface of different breadth from the under, giving as a consequence sloping edges, as at *c c*, *d*, or *e*, fig. 19; to make the "board" or "plank" a perfect rectangle in section, as at *f*, so that its edges would be square to the surfaces or sides, the sloping part, as at *g e*, would be cut off, so as to leave the edge vertical, as at *h*.

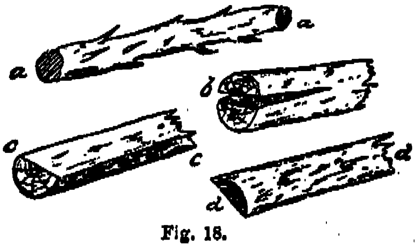

Fig. 18.

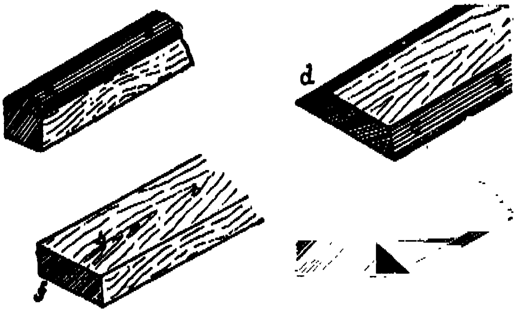

Fig. 19.

The Cutting up of Trees, or Parts of Trees, into Timber for the Early Work of the Carpenter.

The uses to which flat-surfaced boards or planks could be put would rapidly multiply as construction and the consequent desire for comfort demanded by many consumers progressed. And when saws could be made large enough and strong enough, they would be soon and extensively employed in cutting up or dividing in the direction of their length round timber of such diameter as would give more than the two planks or boards which the method illustrated in fig. 18 would yield. This process is roughly illustrated in fig. 20, in which *a b*, is supposed to represent the end in section of a tree or a large branch of it. By sawing down on each side of the central point, as at *c c*, *d d*, the plank or board of greatest breadth, as *c c d d*, would be got which the piece of timber

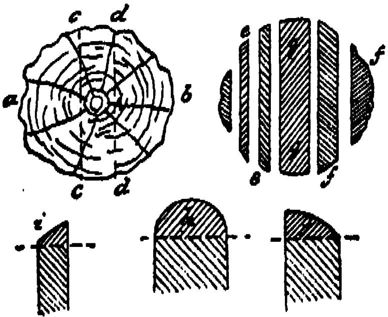

Fig. 20.

would be capable of giving. By again sawing down vertically at various points, each remaining half, as *a* and *b*, so many boards, forming altogether a series of which *e e*, *f f*, is a rough representation, would be obtained; *e e* representing the boards or planks yielded by the part *a*, *f f* those by the part *b*, the central one *g* corresponding to *c c d d*. Being cut out of a circular bole or branch of a tree, the edges would be more or less rounded, as at *h*, *i* and *j*; the edges could be made square by cutting off across the dotted lines either by saw, axe, chisel, or adze.

In like manner, when beams capable of either supporting or carrying heavy weights were required—as they would be as the desire to have larger and better structures increased—they could be cut out of boles or trunks of trees or of large branches, somewhat after the fashion shown in fig. 21. We have alluded to the value of flat surfaces as being early discovered by the carpenter. These would be specially useful in the case of beams supporting heavy weights, inasmuch as they would enable the beams to be placed in position much more securely than if their surfaces were rounded. In other words, a flat surface would better give what in modern technical phrase is termed a "good bearing surface" than would a round, which would obviously present a rocking or rolling surface when lying on a flat place, technically now called a "bed" or bearing place. The quickest way to get a beam from a tree or branch would be to cut or square off two sides only, as at *a* and *c*, fig. 21, giving two corresponding flat surfaces and two rounded edges as at *b* and *d*. A square beam would be obtained with four flat sides by cutting or squaring off the four rounded parts as at *e f g h*. The reader will find at an advanced part of the present series of papers a method of finding the strongest section of a rectangular beam which can be cut out of a round bole or trunk of a tree. Further on, also, he will have various diagrams given him illustrative of the points which regulate the forms of beams calculated to support the greatest weights, and how the pressures exerted upon beams are measured and estimated.

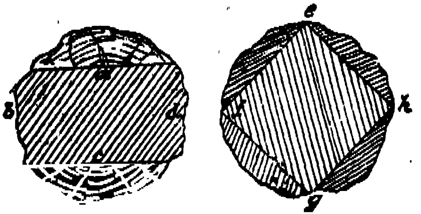

Fig. 21.

"Framing," or "Framework," an Assemblage of "Pieces" or Parts of Timber in the Construction of the Carpenter. —Some Technical Points connected with the Subject.

So far as we have gone, we have been concerned chiefly with the methods of joining timber together, in using and in cutting it up, and with explaining in conjectural fashion the possible way in which the methods were discovered by the early workers in timber construction. But we have only incidentally touched upon what constitutes true "framing." By this term is meant an arrangement of timbers more or less numerous by which with the least weight or bulk of material the stringent form can be obtained. This arrangement is called an "assemblage," or an "arrangement," or often simply a "framing" or "framework," and may take various forms, of which floors, partitions and roofs are those principally met with, although there are numerous other forms, such as those in scaffolding and framework used in the construction of public works, as harbours and other departments of civil engineering work. Of all of these, illustrations in abundance will be given in the course of these papers. The assemblage of any framing is, as we have said, made up of a number of independent or separate parts joined or connected together; and to these parts the name of "members" or "pieces" is technically given. Those assume different positions, and take different names—such as girders and beams, rafters, purlins, struts or braces, ties, king posts, and the like. Of all these also, and the joints used in connection with them, the pupil will find ample illustration in succeeding chapters.

In endeavouring to trace the gradual progress of the art of carpentry in one of its leading departments, the pupil will very much have misconceived our aim if he supposes that we have been giving what may be considered as matter which is merely interesting, or, as some may even consider it, only amusing. It may be this; and we are so far from objecting to any study being so lightened up that we would, on the contrary, advise all young students to use such "legitimate means" as judicious amusement affords to lighten and instruct them in its necessarily dry details. But if what we have said be amusing to some, it is something, and designed to be something, much more than this. The pupil will have read to little purpose in the direction in which we have designed to lead him if he has not perceived the practical aim of what we have given, or has failed to gather from it much information of a thoroughly useful character. Whether the conjectures we have given in preceding paragraphs, and are about to give in those to follow, be more or less accurate, or altogether fanciful, they actually embody some of the most important principles of the art of carpentry, the fuller exposition of which will be found in succeeding illustrations and descriptions. And if our conjectures as to the details of progress, or what was likely to be in early practice, appear to him to be feeble, or to possess no force at all, we should recommend him to endeavour in somewhat similar manner to our own to conceive for himself such steps as would probably be taken by the first workers in timber. This will possess more than the mere advantage—though that in itself is worth something—of ministering to the intellectual training which the habit of thinking out for himself the different points of the art is calculated to give; it will moreover aid him greatly in his estimation of the principles upon which that art is founded.

We have said that we have not as yet considered closely the subject of "framing," purely so called, and the meaning of which we have but just generally described. In much the same conjectural way we have followed, or attempted to follow, the progress of the art in two of its departments, we shall now attempt to follow it in this the most important of those. And here we shall be, if not disappointed, much mistaken if the pupil does not derive some practically useful information as to the leading principles upon which all framing is constituted.

Gradual Development of the Art of Designing and Constructing Framing or Framework by the Early Carpenters.—Simplest Elements of Framing.

The knowledge of those principles would naturally be a matter of slow development; and the first or tentative attempts to erect structures of timber possessing the greatest strength to resist opposing pressures or sustain heavy weights, would gradually lead up to a study of the reason why certain arrangements of pieces of timber gave greater strength to the structure than other arrangements. In this, as in other of the mechanical arts, the practice of certain contrivances would precede the principles, and these would only be deduced from the simple practice when men had further advanced in intellectual analysis and synthesis, or in what is called scientific reasoning; and still higher developments in practice would lead out from still deeper study into the application of the first or elementary principle which practice would display. This practice would, in one sense, be forced upon the early workers in timber from the mere necessities of their position. They would feel that their growing wants and the claims of a higher civilization demanded, if not more and more elaborate, certainly stronger and still stronger structures. Nor would these wants and claims be altogether of the class which some think alone constitute true civilisation. Man has been defined as a fighting and a quarrelsome animal, sharing in this way with the brutes a capability of inflicting suffering and loss upon his neighbours. And as ill weeds are said to grow apace, we may very reasonably conclude that warfare, in one or other of its many more or less but always too decided forms, afforded a much earlier impulse for the timber worker to give strong structures for defence, or strong appliances for offence, than any necessity arising from the pursuit of greater and more humanising influences. The mechanical arts have, as a rule, showed many of their best and earliest developments in connection with what is called the art of war. Hence trenchant swordblades were common long before domestic knives or scythes for the grass-mower were met with, and spears received more of the attention of the artificer in metals than did pruning hooks. And as the best materials and the finest workmanship were given by the metal artificer to the implements of warfare, so was it, we may reasonably conclude, with the worker in timber. He would for a long time be much more frequently called upon to design and construct a strong structure for defence in war than he would be asked to rear a strong yet comfortable house for time of peace.

We may reasonably conjecture that the first element of a piece of pure framework was obtained in the way illustrated at *a b c d*, fig. 22. We may suppose the post *a b* to be one fixed by being made to penetrate the soil or ground, that part of the post or stake being pointed, as shown by the dotted lines. It was desired that the post so far firmly fixed by its hold or grip of the soil should be capable of resisting any attempt to make it swerve from one side to the other. We may suppose that whatever pressure was likely to cause this elevation from the vertical would come from the side and be represented by the arrow *e*. A very slight knowledge of the way in which a pressure was put upon a post so placed, and of that in which it would be best resisted or neutralised, would

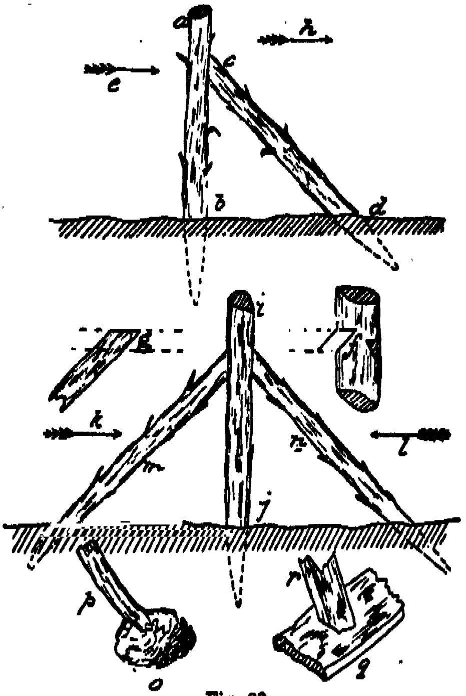

Fig. 22.

give the suggestion of propping it up—to use the popular phrase—by putting a piece, *c d*, in the position shown in fig. 22, one end pressing against the post, as at *c*, the other pressing on or penetrating into the soil at *d*. The simplest way of securing and keeping up the connection of the end *c* with the face of the post, *a b*, would be to notch the post, as at *f*, slightly tapering off the end *c* of the prop *c d*, as shown at *g*.

This arrangement would dispose of any force in the direction of the arrow *e* "pressing" on one side of the post, or "pulling" on it in the direction of the arrow *h* from the opposite side. To oppose a pressure on a post, *i j*, fig. 22, "pushing" in one direction, as shown by the arrow *k*, and another "pulling" or hauling in the opposite direction, as indicated by the arrow *l*, a repetition of the contrivance adopted at *c d* on the opposite side of the post would so far meet the case. It is, of course, obvious that much of the capability to resist any of the pressures here named would depend upon the strength of the prop *m* or *n*. If weak it would bend, and possibly break. The early workers in timber, however, would be careful to use timber strong enough, and this we know they did from the examples of carpentry which have come down to our time in old buildings. But strength alone would not secure the prop doing its work, or rather performing its office properly. We have alluded in preceding paragraphs to the value of the principle of "penetration," and the importance of "bearing surfaces." But while valuable in one direction, penetration is a source of loss in another. While it is obvious that the end *d* of the prop *c d*, fig. 22, would have a good position or anchorage given to it by being inserted in the soil, it is equally clear that under pressure put upon the prop by any force "pressing" in the direction of the arrow at *e*, or "pulling" in that of the arrow *h*, it would have a tendency to penetrate deeper into the soil. And the further the point *l* sank then, the more the point *c* would yield, and the greater would be the swerving of the post *a b* from the vertical or its strongest position.

Technical or Practical Facts learned from the Foregoing Illustration.

We have alluded to "bearing surfaces,"—and as to their value the early workers would learn somewhat from their experience in carrying out such a contrivance as that illustrated in fig. 22, at *a b c d*. It would show that mere strength would not enable a member, such as a prop, to fulfil the duty expected of it. Neither would the accuracy of its position in relation to its connected members. They would soon find that something more than those two otherwise essentials would be required. They would find this to lie in the having a good point of resistance, and in this they would see also the value of the bearing surfaces we have alluded to. Still following out the conjectural style of inquiry we have hitherto adopted, and which, as we have endeavoured to show, is likely to give the pupil many practical suggestions, we may conceive the following to have been the experience of an early timber worker. In erecting the arrangement or assemblage of timber illustrated in *a b c d*, fig. 22, he found that on first inserting the prop *c d* it appeared to strengthen or support the vertical position of the post *a b*. But as the pressure was brought to bear upon this which we have supposed to be exerted in the direction of the arrow *e*, he found that somehow the post continued to lean towards the arrow *h*, and on examination he would find that this happened precisely as the end *d* of the prop *c d* sank deeper and deeper in the soil under the pressure communicated to its upper end *c*, where it was connected to the prop. The pressure on the post still continuing, he would at one point see that it was now able to resist it, and that it remained steady with no inclination to move in the direction of arrow *h*. Curiosity rightly directed is a valuable characteristic in man, and is one of those faculties with which he is endowed, which, when it is judiciously exerted, has enabled him in times past and still enables him to push inquiry till valuable discoveries are often made; and always at the least, at all events, to obtain much valuable information. Against a vain and idle curiosity we need give here no word of warning, as we trust it is unnecessary in the case of our readers. This feeling of curiosity we conceive as prompting the early worker in timber, in the circumstances named above, to try to ascertain how it was that the pressure tending to bend or force aside the post *a b*, fig. 22, was at last arrested. To gratify his curiosity, then, we suppose him to have scraped or dug away the soil surrounding the end *d* of the prop, in order to lay its extremity bare. In doing so he found that its extreme end was pressing against a stone, with which it had accidentally come in contact. Correct curiosity leads generally to inquiry, and inquiry to conjecture, and this is put to the test of practice; he therefore put more pressure upon the post, and found that this caused pressure on the stone. Further investigation led him to discover that this pressure caused the stone itself to "give" or "yield," and to sink into the soil more or less easily; and this not in a direct line, but more at one corner than another. This he found arose from its shape; and at last a gleaming of the fact came into his mind—that the larger the surface or the flatter the stone the better is it able to resist the pressure. Further, that the position of the point of the prop *c d* itself in relation to the stone surface on which it presses affects favourably or otherwise the capability of the stone to resist the pressure of the prop.

THE LAND DRAINER.

DRAINAGE OF LANDS OR SOILS SUITABLE FOR THE CROPS AND LIVE STOCK OF THE FARMER.—ITS HISTORY, PRINCIPLES, AND PRACTICE.

CHAPTER I.

Introductory.

FROM its being the source not only of the necessaries, but also of the comforts and luxuries of life, agriculture would undoubtedly be the earliest as well as the most important employment of man in his civilised state; and draining, as will be presently shown, being the basis of every improvement in the cultivation of the soil, it, in some form of the art, would probably be practised at a very early period of the practice of agriculture, even when such was characterised by its simplest or primary features. The reasonableness of such a supposition is supported by the account contained in the sacred writings of the irrigation of the deltas of the Nile by the waters of that river in the time of the Pharaohs of Egypt, with the object of the increased fertility of the soil, with which operation that of efficient draining would of necessity be combined. That the Romans, that wonderful race, who were so practical in all they concerned themselves with, had systems of drainage for their cultivated land, is abundantly evidenced from their writers. Some of these have, indeed, given descriptions which in detail are wonderfully minute, considering the circumstances under which they wrote. As they carried their systems of polity wherever they made a conquest and established a colony, our country, amongst other benefits which it received from the Romans, received at least the germs of a system of land drainage, upon which, through the successive improvements of ages, our modern system is based. Thus we have in early records evidence that the Anglo-Saxon colonies which peopled certain districts of England, after the final departure of the Romans, kept up, to some extent, the system of drainage on the cultivated lands which they had left behind them. And there is every reason to believe that after the establishment of Christianity in this country the monks took care to keep up the practice of land drainage which they had found established, if not to improve somewhat upon it. We shall in future paragraphs, and by the aid of diagrams, show the way in which, in all probability, the modern system of drainage was gradually introduced amongst us.

Whilst the only vehicle by which nourishment can be conveyed from the soil to the plant is a liquid one, and this derived primarily from the rain and snowfall, and from dews deposited on the surface of the soil, yet when the water is in redundance and stagnant in it, it is unfavourable to vigorous and healthy growth, and to the maturation of the fruits of vegetables of almost any economic value. The exhalations from the vaporisation of water from wet grounds, moreover, render the surrounding atmosphere unhealthy, and engender disease in cultivated crops, as well as in mankind, and amongst the domesticated animals, which live on the produce of the soil. These evils can be obviated by providing for the escape of redundant water from the soil by thorough underground drainage, instead of allowing such water to be conveyed from the soil by evaporation. The grazing on wet pastures is, of all others, a most active source of very malignant and fatal diseases in cattle, and is the certain destruction of sheep. In brief, wetness of the soil is a complete hindrance to every tillage operation; and unless the soil is free from perceptible wetness, manures of any kind—either mineral or putrescent, or whether the same act chemically or mechanically—have little or no effect in recruiting exhausted or in supplying increased fertility. Increased depth of stirring wet, retentive soils, without providing means for the passing off of the water by ducts below, so far from producing increased fertility, only increases the sterility of such soils, by furnishing a more extensive reservoir for redundant and stagnant moisture below the surface; and, as we shall see presently, the reduction of their temperature—and a normally low temperature—is always an accompaniment, if it be not one of the most potent causes, of decreased fertility.

Object of Drainage.

The object of efficient draining is not to deprive the staple or even the subsoil of that degree of healthy moisture necessary to the nourishment of vegetables; but rather, by a subterranean outlet, to free the subsoil from injurious wetness—entering, it is true, by the insterstices between the particles of the surface soil, but retained in redundant quantity by reason of want of porosity in a subsoil more or less dense. Such is the most common cause of undue wetness of the staple soil, and which is mostly to be witnessed in ground having a contour of surface favourable for drainage. Another cause of undue wetness of surface soil arises, however, from moisture rising from below, by absorption through the subsoil from a very pervious stratum of sand or gravel, at a still greater depth, charged with water received at a higher elevation than the surface above such wet bed. Such causes of wetness are to be found both on declivities and on flat, low-lying grounds: when the former-mentioned situation is the case, the wetness is to be detected in outbursts of weeping springs, easily to be dealt with; but, in the latter case, a uniform unhealthy dampness of surface is the result, only to be got rid of by draining—frequently at much labour, difficulty, and expense. From the foregoing remarks it may be perceived that the object of field draining is not to remove water immediately from the surface, but rather to encourage its percolation through the surface soil, to be conducted by passages or drains from the subsoil. But while this is what may be called the main or primary work of land drainage, it is imperatively necessary, as we take it, that the reader new to the subject should bear strictly in mind that this work brings with it an advantage of the highest practical importance. And this is the facilitating of the action of the atmospheric influences upon the mass of soil under the surface and within the range of action of the drainage system adopted. That these atmospheric influences are of the highest cultural value, requires for the present simply to be stated; some proof of it will be given in the paragraph succeeding this, and fuller details will be found by the reader desirous to understand thoroughly their bearing on the present subject of land drainage in the series of of papers in the present work entitled "The Farmer as a Technical Workman." So powerfully advantageous are the atmospheric influences—here only alluded to—in a cultural sense, that some authorities (and we confess that we are inclined to go to a great extent with them) hold that the chief advantage of drainage is that it puts the under-surface soil into that condition which permits of the action of those influences. Giving, however, no undue prominence either to the one or to the other of these two objects of land drainage, it may safely be defined as a method of treating the cultivable or cultivated depths of soil in such a way that all excessive supplies and stagnant accumulations of water may be removed from, and the benefit of the atmospheric influences conveyed to it. This definition, while we believe it to be strictly accurate, is wide enough to embrace every point which has relation to the subject.

Deep Drainage—Popular and Fallacious Ideas respecting it.—Aeration of the Soil an Essential Part of its Functions.

The ideas prevalent to a large extent, even amongst the classes who live by farming, on the subject of deep drainage shows how much there is yet to be learned respecting it. And if this be the case with many of that class so obviously deeply interested in correct knowledge of a subject avowedly of immense importance to them, it can scarcely be expected that those classes who do the actual, or what may be called the labourers' or artificers' work of drainage, will be better informed about it. Apart from its importance agriculturally, there are so many points of interest attached to the subject as a mere technical trade that we shall do the reader a service if we take up a little of his time in drawing attention to its leading points. The generally held opinion, even amongst many farmers, respecting drainage, or rather the work which it has to do, is that it has only to withdraw or carry off the water from the soil. Now, while this is true so far as it goes, it has other and very important offices to perform. It is only recently that the beneficial effect of the atmospheric influences, as they are termed, alluded to in the preceding paragraph, upon such soils as may be laid open to or are exposed to them, has been fully recognised. We have not space to enter into this very interesting subject: suffice it to say that so powerfully do they operate upon the soil, that some go the length of asserting they bring it into a condition much better fitted to receive the seeds of our cultivated plants than can be effected even by the most elaborate system of mechanical cultivation or working. While this may be taken as an exaggerated view of the point, still it tends to convey some idea of the important part the atmosphere does play in fitting the soil to bear crops, and in maintaining their growth till they reach maturity. The importance of the atmosphere as an agent, both indirectly and directly, in the fertilisation of the soil, cannot be, and is not, denied by those acquainted with what may be called the principles of cultivation. The more direct and detailed consideration of the subject will, as we have said, more fittingly occupy a special place in the chapters taking up "The Farmer as a Technical Worker." We shall here concern ourselves only with the way in which the air is enabled to act as an indirect—or as we may call it a *mechanical*—agent in fertilising soil or bringing it into a condition fitted to give out its maximum of fertility, and this through the agency of drainage. What drainage now practically is, and by what steps it was gradually introduced as an important, indeed essential factor in the solution of the problem of how best to cultivate land to bear crops and maintain live stock or the domestic animals on their produce, will be described further on.

General and Brief Statement as to how Drainage of the Soil is Effected.

Meanwhile it is only necessary to state that the drains so called are made up of a series of hollow tubes of earthenware deposited end to end at the bottom of trenches cut in the soil at greater or less distance on or over, and at varying depths under, the surface of the soil. The tubes are laid end to end so as to form a continuous tube or channel along which water can pass, and on such an incline or slope that, entering at any part of its length, it flows naturally but slowly and gradually from the upper or higher parts to the lower and ultimately to the lowest point, where it is delivered either to a larger tube or to the ditch or watercourse forming the ultimate point of delivery. And although laid end to end and forming continuous tubes or water channels, the various joints —one joint being formed at the junction or juxtaposition of two contiguous tubes—are not cemented to form what are true or impervious joints, but are left free, so that each junction point, where the end of one tube butts or lies against the end of the tube next contiguous, forms an open space or ring through which any water passing from the surrounding soil is free to pass through it and enter the tube, which, being on the slope or lying upon an inclined bed, is carried away to the lowest point of final delivery. It is scarcely necessary to say that after the drain tubes are laid along the beds of the various trenches cut in the soil, those trenches are filled up and the surface of the land left free for the various operations of culture. The drain tubes are thus imbedded in and surrounded on all sides by the soil.

The Mechanical or Physical Condition of a Drained Field.

We have thus in each drained field a series of hollow chambers, all of which, although in one sense air-tight—that is, considered as a whole—are left free for the passage of air through from end to end, and each joint of which acts both as an air and a water passage. And when we further point out that a field may have not merely a series of drain tubes or air and water chambers, or rather conduits or passages, placed at distances parallel to one another, but tubes acting as cross drains and as subsidiary and main drains, the actual details of which will hereafter be fully explained in the present series of chapters, the reader will perceive how the under soil may be cut up, so to say, into a series of compartments by drain tubes, the several joints of which form in the aggregate a numerous collection of open spaces for the passage of such air and water as may reach them. And as all these open into tubes, and all the tubes ultimately and finally terminate at points open to the external atmosphere, he will perceive that there are at least the means by which large volumes of air may be carried into the very heart, so to say, of the soil. We do not here enter into a minute detail of the way in which air is supplied or carried to those tubes by the action of drainage: this will be done in a succeeding chapter. Suffice it now to say that the water shed on the surface of the soil by rain, by melted snow or ice, or by deposited dew, as it percolates through its particles, and descending from the surface, passes to the lower strata, where it is arrested, so to say, by the drain-tube passages or joints, passing through them to the interior of the tubes, carries down with it certain volumes of contained air; and not only so, but in a way which will be hereafter explained, drags down mechanically with it certain other or extra volumes of air. If, then, air be beneficial to soils—and how highly it is so, and in what way, the reader will find fully detailed in its proper place in the papers entitled "The Farmer as a Technical Worker"—it is obvious that drainage does act in another way than merely by getting rid of by carrying it away all superfluous moisture or rather wetness or excess of water present in it. One of the advantages of this aeration of the soil may here be noticed—and that is, increasing its temperature, which increase has a marked influence upon its fertilising capabilities.

Deep or Thorough Drainage raises the Temperature of the Soil.—Practical Points connected with this Valuable Feature of the System.

By thorough draining the temperature of the soil is raised 1½ to 3 degrees of Fahrenheit's thermometer: such variation in the increase of temperature of the soil being due to its nature—the less retentive of wetness, or more open, the warmer it becomes. It should be remembered that an increase of a degree of temperature represents ·9 of a degree of lower latitude, and that a decrease of a degree of temperature is equivalent to an elevation of 280 feet; that *one cubic foot* of water in the process of evaporation deprives *three millions of cubic feet* of air of one degree of temperature; and that an undrained field growing rushes has a permanent temperature of from 4 to 6 degrees lower than an adjoining field—drained—growing wheat.

When speaking of redundant wetness in soils, the supersaturation of soils by water is intended to be understood. Different earths require a different quantity of water for their saturation. When the water in a soil exceeds the quantity it will hold, it will be perceptibly wet; and the excess of water will leave the soil if there be means for its escape. This is the condition of soil under supersaturation of water, or redundant wetness.

Differing Capacities of Soils for Absorbing and Retaining Water.

The mineral earths have not the same power of either absorbing or retaining water. Of these the most readily absorbent of water are the least retentive of it. Soils, however, containing much vegetable and animal matter are both more readily absorbent and retentive of water than almost any of the mineral earths; and peat soils, which consist almost entirely of vegetable matter, absorb water much more readily, in much greater quantity, and possess a much greater power of retaining it, than any other.

According to the experiments of M. Schubler, the amount of water contained in one cubic foot of the undermentioned earths when saturated is shown by the weight prefixed to each:—

Calcareous sand . .	31·8 lb.	Garden mould . .	48·4 lb.
Siliceous sand . .	27·3 „	Arable soil . . .	40·8 „
Sandy clay . . .	38·8 „	Fine slaty marl . .	35·6 „
Loamy clay . . .	41·4 „	Gypsum powder . .	27·4 „
Stiff clay or brick earth	45·4 „	Fine carbonate of lime	47·4 „
Pure grey clay . .	48·3 „	Fine carbonate of magnesia . . .	62·5 „
Pipe clay	47·7 „		

Value of Drainage in respect to Droughts.

Rain-water rapidly absorbs heat, but it can only convey it downwards with itself; and in its passage to the drains it imparts to the soil the heat it has received from the solar rays and from the heated surface of the earth. But if, on the other hand, rain-water cannot descend, either by reason of natural non-porosity of subsoil, or from the absence of artificial drainage, it will stagnate at the surface and be projected as vapour into the atmosphere, by which the soil will be deprived of the amount of heat required to produce the evaporation. However, of all other effects of drainage on the physical condition of soils, the most remarkable, and at the same time the most important, is that of counteracting the effect of drought, and which will here be described in the words of Mr. Josiah Parkes, the most eminent drainage engineer of the age, and the most reliable authority on all that relates to both the theory and practice of land draining. The description in question is from a paper in vol. v., part 1, of the first series of the *Journal of the Royal Agricultural Society of England.*

"If a soil be sufficiently permeable to air, and not saturated with water, it is in a state to receive accessions of moisture from the atmosphere, which is a constant and inexhaustible vehicle of humidity; and if the temperature of a sufficiently porous subsoil be at or below the dew point, as will frequently be the case during some portion of the day in the summer season, the process of depositing dew will take place in the interior parts of the soil during the day at the same time that the exterior, or surface of the ground, may be projecting both heat and moisture into the atmosphere. This process is evidently dependent on the relative temperatures and degrees of aqueous repletion of the air and subsoil at a given time; and independent of the hygrometric power of the latter—which is, however, a potent auxiliary to the acquisition and retention of atmospheric moisture by soil, particularly in its interior parts. Thus, it is apparent that the acquisition of moisture by soils, in the form of dew, is not limited to the period of night only, nor to the surface of the earth; and it has been shown that the precipitation of dew cannot take place without the communication of heat to the recipient substance; hence the importance of sufficient pulverisation to permit access and change of air to the interior parts of the soil. One of the most beneficial effects of drainage may be also safely presumed to arise from its facilitating the access and change of air to the very bottom of the bed; as in proportion to the escape of water, so will be the entrance of the air, which will, *pari passu*, occupy the place vacated by the water.

"Every observant farmer must have remarked that the amount of dew precipitated during the same night varies greatly on different soils in fallow, and still more on the leaves of different plants. Well pulverised soils attract much more dew than those which are close and compact, as the radiation of heat is effected from many more points in highly comminuted than plane surfaces. Sands appear to be powerful attractors, and in some countries to depend altogether on the nightly deposition of moisture for the support of vegetation. An extreme example of the derivation of the aqueous element from dew alone, and of its highly fertilising qualities, is afforded by the fact that on the sandy plains of Chili rain is scarcely ever known to fall, yet that soil, which under other circumstances would be sterile, is maintained in a productive state by the active forces of radiation and absorption. The temperature of the soil is moderated during the period of the sun's action by the large amount of heat carried off combined with vapour; whilst the exhausted humidity is replaced by dew deposited during the resplendent nights of the tropical region. Instances are also on record of the flourishing growth of trees in Africa on sandy districts, never refreshed by rain or springs, nor by artificial supplies of water; whilst soils of another nature, in the same latitude, and not far distant, require irrigation to enable them to sustain vegetable life.

"In Britain we have, generally speaking, to combat excess of moisture, accompanied by a low and inconstant solar heat. . . . By establishing a free passage for water through the soil, the greater heat of the surface may be carried downwards, and the mean annual temperature of the mass of the soil thereby permanently raised."

Relative Power of Soils to absorb Water.—Retentive Soils.

On the subject of the power of soils to absorb moisture from the air, the following results of experiments by M. Schubler may be quoted:

Sandy clay . . .	26 tons per acre
Loamy clay . . .	30 „ „
Stiff clay . . .	36 „ „
Garden mould . . .	45 „ „

So that on efficiently drained land in a high state of condition and cultivation, crops will not suffer to any serious extent from the effects of drought; and wherever the loss or extensive damage of crops has been the effect of drought, such has arisen from want of draining, or from poverty of condition, or imperfect cultivation, of the soil.

The benefit of draining is not alone confined to wet and retentive soils, but it may extend also to those of an opposite character. Soils which are not sufficiently retentive of water to furnish the moisture necessary for the growth of plants—such as clean gravels and sharp sands—may frequently be much improved by draining. The manner in which draining tends to improve these unretentive soils will be briefly explained in next chapter.

THE STEEL MAKER.

THE DETAILS OF HIS WORK—THE PRINCIPLES OF ITS PROCESSES—THE QUALITIES AND CHARACTERISTICS OF ITS PRODUCTS.

CHAPTER I.

Introductory.

To have written even an extended or detailed notice of the steel maker's art and work some half a century ago, or even a much less period than that, would have been a comparatively easy task. It would at all events have been somewhat difficult, unless the minutest details of practice and such theory or theories as were at the time available had been given, to have made the paper a very long one. Now, however, such a paper, if the subject is to be done justice to, has to deal with such a variety of topics, to notice such a number of new processes, and to glance at such varied theories as propose to account for the different phenomena displayed by the different styles of manufacture, that the difficulty is to select from the vast mass of materials which the work, especially of the two last decades, has placed at the command of those interested in the subject. When there is so much that is good, it is no easy matter, under the claims of a limited space, so to select from this that nothing is passed over which should be at least noticed, if not fully described. This new phase of the trade of the steel maker, or new era in its history, has had its origin in the introduction, within the last twenty or five-and-twenty years at the outside, of methods of producing from iron new metals which in modern or popular phrase are called steels, but which, as we shall presently see, are in the opinion of not a few scarcely entitled to range in scientific nomenclature with the metal which for long centuries was known all the world over as "steel," and which possessed peculiarities not belonging to the modern steels, so called, or if those possess them they do so only in a limited and more or less modified degree.

Whether those new metals, in the discovery of the working of which some of the most brilliant successes of modern science have been secured, are or are not entitled to come within the range of the precise definition which decides what the old form of steel as a metal used in the art was, is a disputed point. But the fact, at all events, remains, that, known by one name or another, they are produced in enormous bulks or weights, and are used, or are capable of being used, for a wide variety of purposes in construction of all kinds, to such an extent as the most sanguine connected with the old and, as many will still doubtless call it, the legitimate trade of steel making, would never have dreamed of. In the old—which come up, indeed, to what may quite truly be designated very recent—times the steel maker addressed himself to an audience which was exceedingly limited compared with that of which the makers of the modern steels so largely gain the ear. The *clientèle* or customers of the makers of the old or only form of steel then known and available for practical purposes were the limited class requiring steel for the manufacture of tools and implements possessed of cutting edges; any extended use for it beyond this was not even dreamed of. And although recently the old steel or method of making it has been adopted for objects larger in bulk and for purposes quite beyond the ideas of the old members of the trade, this new outlet owes its origin to, or was the fruit of, the impulse given by the methods of making the new metals, or steels as they have been called, and which methods are capable of turning out articles practically unlimited in bulk or weight.

The Relation of the Modern Steel Maker to the Engineer and Machinist using the New Forms of Steel made by recently introduced Processes.

The modern steel maker—taking him, for the purposes of our paper, as one engaged or interested in the making of the new as well as the old forms of it—addresses in this state of matters a very wide class, made up of the great number of engineers and mechanics who are engaged in the designing and erecting of all those new kinds of structures, and the wide range of machines demanded by the growing wants of a great, a numerous, and a wealthy people. They are thus brought face to face, in the closest and most practical of business relations, with that large class of which the various members may be said to come under one common designation—namely, mechanical. It is, therefore, a matter of no small moment for those who make what is now in reality a wide variety of steels to have a good understanding with the users of it, who can thus throw in their way, what all engaged in trade of any kind like well to receive, "large orders." And before proceeding with the details of their manufacture, it will be well to glance at the position of the trade, who make, to the mechanical callings or professions who use, these different steels. The inquiry will carry with it its own points of practical interest to both, while it will also serve as a useful introduction to the details of the actual processes of the steel maker.

So much has of late years been written on the subject of the new processes of steel making, and so frequently has attention been called to their influence in revolutionising, as the phrase has been so often used—the trade, and in introducing altogether a new era in metal production, that few of the readers even of the ordinary daily journals, can now, at this date, be supposed to be ignorant of the fact that something very important has been done in one of the largest industries of the many which have added so much to our national wealth and influence. As a matter of course, the readers of those journals more or less exclusively devoted to practical science, even when they have been of the most careless and unobservant, must for the last decade or two have been more accurately and more extensively made acquainted not only with the fact that great innovations had been made in the iron and steel manufacture, but must have had some conception given to them of what the principles were upon which they were based. Even with such careless readers the names of "Bessemer" and of "Siemens" must have been as "familiar as household words," and general statements of the enormously increased production of one of the new products—steel—must have been accepted as what may be in like manner called household facts.

The Large Production of the Modern Form of Steel—so called—a Striking Feature of the Trade as compared with the Limited Production of the Older Form of True—so-called—Steel.—A Greatly Extended Use of Steel in Construction the Result of this.

Previous to the introduction of the new and revolutionising processes of *steel* making, the production, as we have already hinted at, of the metal so widely and universally known by this name, was limited to a weight very small indeed, compared with that of the works throughout the kingdom carrying out the Bessemer process, with their annual yield of thousands of tons, and those working on the Siemens-Martin process, with a less, but still a large production, of this commodity. But not only was the production of steel very limited before the date of the introduction of those new processes: its uses were equally so, being confined almost exclusively to the making of tools for mechanical work, and for the various cutting instruments used in arts and trades and for domestic purposes. So exclusively used, practically, that its narrow use gave rise to the universal definition which recognises steel as a metal, and the only metal which could be tempered and then reduced to a cutting edge of the finest keenness, and hardened so that this fine edge could be made to endure even what might be called hard usage. In due course of time steel began, by the aid of the new processes, to be made in such enormously increased and daily increasing weights, that the tens of tons of the metal representing the production of the old, were replaced or supplemented by the hundreds of tons—if not a much higher rate—of the new methods. For the limited range of uses of the old steel, represented by objects light in weight and small in bulk, a range of utility was substituted to which there was apparently no limit, by which the heaviest and bulkiest articles of mechanical work could be made with the same relative ease as the lightest and smallest. From the making of knives and hand tools the constructive capabilities of steel were extended to all objects, from the steel "permanent way" of our railroads to the heavy and bulky plates required for the building of ships, or the still more ponderous masses which sheathed the sides of our gigantic war vessels, or formed the crank and screw shafts of the powerful steam-engines which propelled them. When all this came about, and, indeed, long before the capabilities and uses of the new metal products had been fully demonstrated and their value thoroughly established, the soul, so to say, of the practical mechanical world was stirred to its depths. At first the new processes were subjected to all the evil and retarding influences which deep preconceived prejudices are unfortunately able to create and encourage. Their inventors, and those far-seeing—at all events unprejudiced and naturally generous-minded—men who supported and encouraged them, were subjected to all the keen invective, the cutting sarcasm, and not seldom to the painful, because untrue, personally painful innuendos and vague surmises, which are the one standing disgrace—let us be thankful it is only one—of the mechanical callings. But this pooh-poohing, and worse, of the new processes, to which all new processes are subjected, and which are the deeper and the more lasting the more they are likely to interfere with what are called vested or trade interests, availed nothing; they continued to improve and to extend, till at last, having beyond all doubt and cavil established themselves as facts in the daily working of our metal manufactories, their results were universally accepted, and the new metals took their place as materials of great value in daily construction.

Some of the Views held by those engaged in Mechanical Construction relative to the new Metals—the so-called "Steels"—as useful in Work.

But with this came juster and graver thoughts on the part of the mechanical world. The characteristics and capabilities of the new metals were more and more studied as their uses became more and more extended. But it was scarcely to be expected that the introduction of a metal which under the same name possessed few of the peculiar characteristics, while it was available for so much wider a range of uses than the old steel, would be received without some doubt or cavil on the part of those engaged in mechanical work. Although not, of course, to the same extent as existed in the minds of those who only took a generally scientific or popular interest in, but were not concerned in the actual use of iron and steel for construction, still many of this latter class viewed the new metal with grave distrust. And this feeling extends amongst practical men over a much larger area than some of our readers may be disposed to think likely to be the case. Many, to the knowledge of the writer of these lines, to whom the new "steels," so called, would unquestionably be of great use in their extensive and extended work, persistently refuse to avail themselves of their help. This doubt as to the real value of the new metals for constructive purposes does not arise wholly from any doubt as to what their characteristics and capabilities *per se* are; but doubts are seriously and honestly entertained as to whether these are available for their particular class of construction—whether they can work them with their usual appliances—and last, but not of the least importance, whether these methods of working and those appliances would not bring about some bad features in the metals, if they are not, indeed, incapable of utilising its good qualities, which up to a certain point, and with certain reservations, they are quite willing to admit. Much of this arises from lack of a thorough knowledge of what the new metals really are, and of what they are capable; and of dislike, perhaps scarcely justifiable from one point of view, to try them and see for themselves whether they could work them up with their methods and with their appliances, and in so testing them to discover whether some modification of them were required. On the other hand, such doubts, they may say, are justifiable in view of all the circumstances. Well acquainted with what ordinary steel is, and of its high value for constructive purposes, if only it could be produced in the large weights and used with the same freedom as the makers of the new metals say they can be used, they simply hold that these new metals are not what they are called—steel—at all; they are in fact, so many say, only good wrought iron.

Contention of Some that the New Metals are not entitled to be classed as Steels.—True Steels.

While quite ready to admit that they may not only be good, but really the best wrought iron which could possibly be produced, they, however, say, "Well, this may be true, but *that* is just the point we wish to have decided; we have had great experience in the use of wrought iron which has hitherto been supplied to us, and that experience justifies our faith in it. We have tried it, others by thousands have also done so, therefore its value is established. Prove to us that your new metals are as valuable and *trustworthy* as this, and we should only be too glad to use them." There is much, very much, in this; and while our readers will absolve us from any, even the slightest, desire to undervalue any new thing simply because it is new, or runs counter to old-established notions or prejudices, and while eager to see progress made in all departments of engineering and mechanism, justice demands that all attention should be paid to a statement so fair as the one we have thus put—and which, in fact, is put forward by so many practical men, representing as they do a large percentage of metal users and workers. They cannot be blamed for exercising caution, and keeping in view the old and profoundly wise precept of the Scriptures, which, applicable as it is to higher aims and nobler objects, is not precluded from use in secular matters—"Prove all things, hold fast to that which is good." Nor can they be much blamed for thus being cautious and careful, when they read, as they easily can any day, the discussions at our scientific meetings, and the papers published by our practical journals, by practical men, who, while advocating the use of the new metals, and actually using them, and in many cases most extensively, nevertheless draw attention to certain points which, if established, do go far to throw at the least doubts upon their altogether sound character, and as to whether as constructive materials they can be used under all circumstances and for all classes of work. Only, on the other hand, let justice be done: while many exercise such caution in the use of the new metals that they practically do not use them at all, and in excuse for this demand proofs of their value, they are bound, as members of a profession famed for its progress, to do all they can to prove the value they desire—as they say—to know. We should never know the value of a thing till some one tried it; and the advocates of these new metals are quite justified in asking those who persist in standing aloof from their use, this question—"What is it which gives *you* the right to ask proofs of their value from others, and to refrain from making any proofs of it yourselves?" Of course, the reply is this: "New products are economical objects; let those who make and sell them do as other commercial men do, prove the value of their wares." But the reply on the other side is much more potent and more difficult to be answered—especially when it is put forward, as it is so put generally by those who are not interested in the sale, but only in the true progress of the constructive arts and in the extended use of the new metals—"True! but in refusing to use what has been, beyond a doubt, proved to be valuable, you are opposing your own true interests." And this really is the practical point. The value of these metals is proved; doubtless, faults exist, but faults exist equally in other metals; and they have gained such a point in practice that they cannot fall back—progress must continue.

Definition of the Term "Steel"—Practical Importance of Accurate Definitions of Technical Materials and Work.

Much of all the doubt and uncertainty existing in connection with the true value of the new metal—we have hitherto called them metals, as practically they are produced by two distinct processes to be yet explained—arises from the unfortunate fact that in its introduction to the trade it was, and is still, designated as "steel."

THE WORKMAN AS A TECHNICAL STUDENT.

How to Study, and What to Study.

CHAPTER I.

Introductory.

In taking up the consideration of this important subject, it may appear to some that it is scarcely necessary to glance even briefly at the advantages which technical education is likely to bestow upon the workman desirous to make practical progress in his calling. No doubt, in a general way the great majority of those who are confessedly indifferent in the matter will readily enough admit that education is a good thing. But there is a wide difference between this merely intellectual, or, as it were, enforced assent to the general principle, and that mental determination to secure by patient application all the advantages which that principle involves. It is not enough that one should be convinced that it is a good thing to perform a certain work; it is only when the work is done that the practical advantages which it brings with it are secured. We should have no hesitation in deciding that a man was—to put the matter mildly—very silly, who persisted in asserting that he was most anxious to go to a certain place at some distance from his home, if he never rose from his accustomed chair at the fireside. His friends would assuredly conclude that if he really wished to go he would at least begin the journey. It is but a very commonplace truism to state that a wish is only valuable practically when it is realised; and no wish can ever be attained without exertion of some kind or another. Good things—all fables and nursery tales, and shall we say the hopes or fancies of those who long ago left the nursery? notwithstanding—do not fall of themselves into one's lap; if a man resolves to be rich or successful in his calling, he knows full well that he must exert himself, give no slothful sleep to his eyes, no rest to the continued labour of his hands or the exercise of his brain. All this seems very familiar, very commonplace; but having some experience of the class or classes we have referred to, we are but too well aware how readily very obvious and common-sense considerations are set aside as practically worthless, simply because they are familiar. And we should see fewer of those practical mistakes made which render some lives lamentable failures, if common-sense and familiar considerations were acted upon, not merely assented to or believed in. Belief is worthless unless it gives life to work. It is to be hoped, therefore, that this all-too-wide class who readily enough give assent to the value of education, but do no more than assent to it, will do something more than this, for it matters little how varied and complete may be the facilities for education if those be not availed of. We have in view, however, another and an infinitely more hopeful class of readers, with whom are associated pleasant thoughts of what practical or technical education will yet be when the idea of what it really is, and what it can do for them, is fairly and fully grasped by those engaged in carrying practically out the varied and valuable branches of industrial work which minister so largely to the material well-being of the community. For although the statement may to some appear somewhat strange, if not startling, it is nevertheless the truth—that amongst those who are not only impressed with the fact that education is a good thing, but give to its acquirement much anxious care, if not great exertion, there are not a few who hold views which are only but too well calculated to dishearten them in their attempts to become soundly educated; if not, indeed, to tempt them to give up all such endeavours, simply because they do not seem to carry with them advantages of a practical character, positively useful to them in their daily work. We propose in due course briefly to glance at what those erroneous views are.

What is Technical Education?

But before presenting to our readers what we may have to say on these vitally important points, it will be necessary, as tending to clear the ground before us, that we may arrive all the more quickly and surely at the place we desire to reach, to glance at one question concerning which it may, perhaps, be matter of surprise to some readers that there is occasion to ask it at all,—and that is, What is technical education? It is quite necessary that this question should be asked; for, apart from the reason that it is only but common sense to know *what* it is one is talking about (not always thought of, this), it will save us from wasting time by talking about things not concerned with the main subject. For, as an eminent writer observes, while one is talking about apples it is but waste of time and of words to introduce the details connected with wheat. But as to our question, one would naturally incline to decide that surely what every one is talking about would certainly be known. There is, amongst the topics of the day which are purely social, scarcely one so much written and talked about as that of "technical education." Speeches are made, lectures more or less learned are delivered, essays published, all pointing to the fact or assertion—for there are some who do hold that it is not a fact—that unless we nationally carry out a thorough system of "technical education," that supremacy in the arts and manufactures we have so long enjoyed will pass from us. And last, if it be not least, a Royal Commission, composed of men presumed to know all about it, has been appointed to examine into and report upon the whole subject, to see whether the above-named assertion be true; and if so, how best this same technical education can be secured, and how carried out. Notwithstanding all this, which one would naturally conclude to be pretty fair evidence that what was so much talked about was known—and although all were not agreed as to how technical education could best be secured, one might have concluded that at least there would be no lack of agreement as to what technical education was—nevertheless we do find that on the very threshold of the whole discussion men have not seldom had to pause, arrested by the question, What is technical education? And we have as a matter of fact found not a few who were puzzled somewhat to give a definite answer to it. There are some, indeed, while not much, if at all, concerned in this question, who rush on to discuss what they assert to be all the points of it. As to the reasonableness of which method one can only say that it does appear to be a matter of some moment that if we will talk about a subject we should know what that subject really is—if, indeed, a subject can be talked about which, not being defined, may be said in some measure not to exist at all. Certainly the wiser heads amongst us conclude that it will be reasonable, at all events, for us to know what technical education is, as tending to help us to decide as to the best way of securing it.

The Difficulty of Defining precisely what Technical Education is.

But those experienced men are by no means agreed as to what technical education is; so that as a result of this uncertainty we have as yet no definition of the term which is accepted by all. Not much prospect of this desirable end being reached when we find one of our ablest men—as practical as he is soundly scientific—stating that "he does *not* know" exactly or precisely "what a technical school is"! If this uncertainty exists amongst many even experienced men, one would be very apt to conclude that there appears but small chance of deciding what *is* to be taught in such a place which duly professes to be a technical "school." What we have said before we may put here in another way: that before we can do a thing we must surely know first what it is we are desirous to do; but common-sense as this view is, it is matter of regret that it is not seldom forgotten in other affairs of practical life besides technical education.

Linguistic Root or Derivation of the Term "Technical."—Some Practical Points flowing from this.

We should not, however, advise the reader to concern himself very much with the niceties of a precise definition; enough if he can hit upon some principle which will admit of so much of a practical explanation of what is to be done in acquiring education or information respecting his calling, in which he, if he be a wise and prudent man, should be desirous to excel. Possibly what we have here to offer for his consideration may enable him to arrive at this practically satisfactory point. The first and most obvious thing to do, in endeavouring to ascertain what "technical" education is, is to see if the established meaning of the term affords in itself any clue to the decision of the special point. What, then, does the word "technical" mean? It is based upon or derived from the Greek word *technikos*, itself derived from *techne*, an art; and "technical" means anything pertaining to or employed in connection with any art. From this comes the science of "technology," in which is embodied the above word *techne*, an art, and another word, *logos*, a speech or discourse—the two together meaning any explanation, written or spoken, of the terms or principles of any art. Here we see that another term or word is inseparably involved in this definition—forms, indeed, its very basis—and to which reference, therefore, must be made. Technology, we see, is—to put it in three words—an "explanation of art." And as the object of all explanation is to impart a knowledge of a subject, and as science is—as we shall more fully see when we afterwards come to inquire into its root and its general significations—really the *knowing* of a thing, we arrive at this other brief definition of technology—that it is the "science of art." To those who remember the usual phrase, heard everywhere, "the arts *and* sciences," as if they were two quite separate things—as indeed practically they are, as we shall in due time see—the above final definition of technology, which is absolutely correct, will give rise to some curious, if not suggestive thoughts.

Meaning of the Term Art—Lesson which it affords in Relation to Technical Education.

This definition of technology, or the "science of art,' may be still further shortened, so that it may be called, and strictly, "art"—that is, everything about it. Now, what is the meaning of "art"? It is derived from the Latin words *ars* or *artis*—these being derived themselves from the Latin root *ar*, to plough. We shall have some remarks to make which may carry with them some exceedingly practical considerations relative to the connection with and the bearing upon technical education which this latter word—or rather, we should say, the lessons which this latter root *ar*, to "plough" or turn up and over the soil—is so well calculated to convey. Meanwhile we proceed to say that the meaning of those words *ars*, *artis*, put into English may be expressed in various ways—all, however, conveying the same idea—namely, that "art" is the ability or power to *do* certain work or to perform certain actions or duties; the use or employment of means or agencies for the doing of this work, the performance of those actions or duties.

THE JOINER.

THE GENERAL PRINCIPLES AND THE DETAILS OF HIS WORK.

CHAPTER II.

In the preceding chapter we explained the form of joint with "quirked" moulding or bead, in which the boards joined are free to give and take without making open joints. These ornamental joints are used in superior work only. In some cases the flat side is relieved by making at the joint an angular groove; this is done by taking off the corner or angle of each adjoining edge. This taking off the sharp corner is called "taking off the arris," the angle being the arris. The same operation is in other cases called "chamfering." (For what are called "chamfers" and "stop-chamfers" see a succeeding chapter, and *b'* and *c'* in fig. 25.) In brick and stone work the same operation is called "splaying" or "bevelling"—a corner being said to be "splayed" or "bevelled." The boards sometimes have the "arris" taken off at the corners of both sides or faces; when a number thus treated are put together edge to edge they assume the form in fig. 6, the upper part of the diagram being in cross section, the lower in elevation. A simpler form of the quirk bead (see the paper on "Mouldings—their Varieties—Modes of Describing and Decorating them") joint for boards joined edge to edge is shown in fig. 7, in which the various parts corresponding in the different views are indicated by letters, plain and accented.

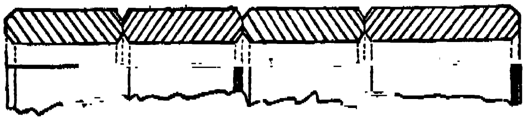

Fig. 6.

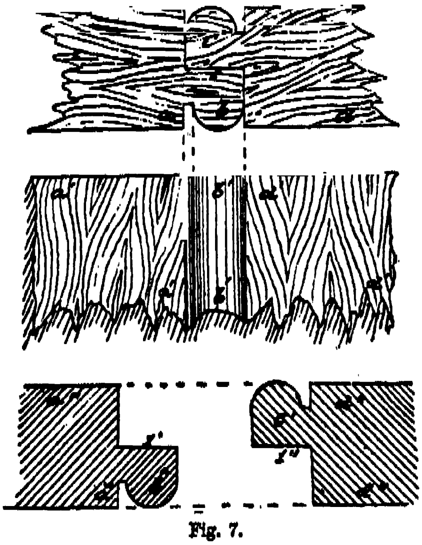

Fig. 7.

Securing Boards joined Edge to Edge by Ledges.

Boards having their joining edges treated in the methods now described in figs. 1 to 7 inclusive, are secured together as in the case of a door, braced or ledged, not panelled (see a succeeding chapter for descriptions and illustrations of the various forms of doors), in various ways. In fig. 8 we illustrate a method very generally adopted in the simpler form of doors, known as a "ledged door." In this case the boards are laid edge to edge with plain joint, as shown in the cross section at *a a a*, fig. 8, and in elevation at *a' a' a' a'*; and in number sufficient to make the surface of the breadth required. A flat, broad "ledge," "batten," or cross-piece, *c c c*, with the "arris" taken off, or chamfered, at each edge on the upper side, is nailed across the surface of the boards *a' a' a'*, and secured by nails or screw-nails; the latter in good work. This batten is usually placed at some short distance from the upper ends of the boards *a' a' a'*, as shown, and another batten is placed at the bottom end of the boards. The whole are shown together in side elevation at *b b*, *d*; *d* being the ledge or batten, and *b b* the edge view of the boards. In the cross section at *a a*, *b b* shows the upper edge view of the ledge *c c c*.

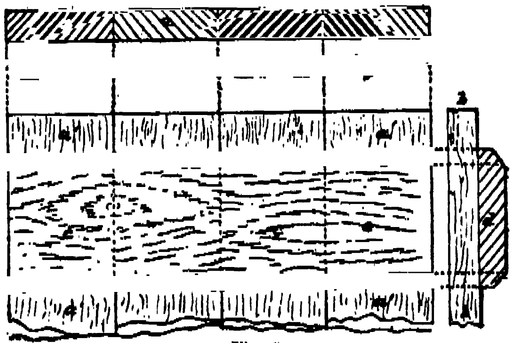

Fig. 8.

Securing Boards by a Dovetailed Ledge or Cross Batten.

In place of the ledge or batten being nailed on or screwed to the surface of the boards, it may be secured as in fig. 9. In this method a "dovetail" groove or mortise (see Dovetails further on), *c c*, is cut in the face of boards *d d*, as shown in face or front elevation at *a' a'*. The "ledge," "batten," or

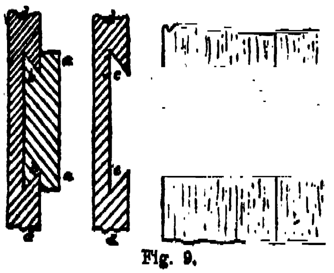

Fig. 9.

cross-piece *a a* is formed with a dovetail tenon (see Mortice and Tenon in "The Carpenter"), *b b*; thus filling up the dovetail mortise *c c* in piece *d d*.

Securing Joined Boards together by means of Cross-pieces or Rails with Surfaces Flush throughout.

In joining boards edge to edge in order to form a larger, that is, broader or wider surface, by the methods shown in figs. 8 and 9, the "ledges" or "battens" *c c*, fig. 8, and *a a*, fig. 9, project from the surface of the boards. In superior work the surface of the united boards is generally desired to be "flush" or even. A method of joining and securing boards placed edge to edge together with the surface of the cross-piece or "flush" with the surface of the boards is illustrated in fig. 10. In this method the cross-piece, as *a a*, runs along the termination of the boards *b b*, which are all cut off "square," but are not left plain, being provided with a "tongue," "feather," or projecting rib, as shown at *c* in edge view *f*. This takes into a groove ploughed out on the edge *c c* of the cross-piece *a a*. The thickness of the cross-piece *a a* is the same as that of the boards *b b*, so that there is no projecting part at the junction, but the surfaces of both coincide or run into one another. The tongue *e* and ploughed groove *c c* in lower diagram are of course made in the centres of the batten *a a* and boards *b b*, *c c*. In superior work the boards *b b* themselves may be joined together by the method illustrated in fig. 2, and as at *g g* in fig. 10.

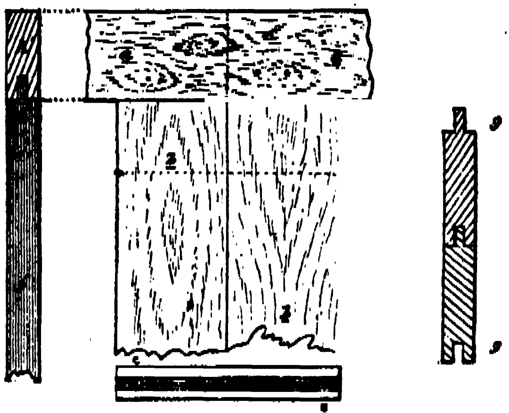

Fig. 10.

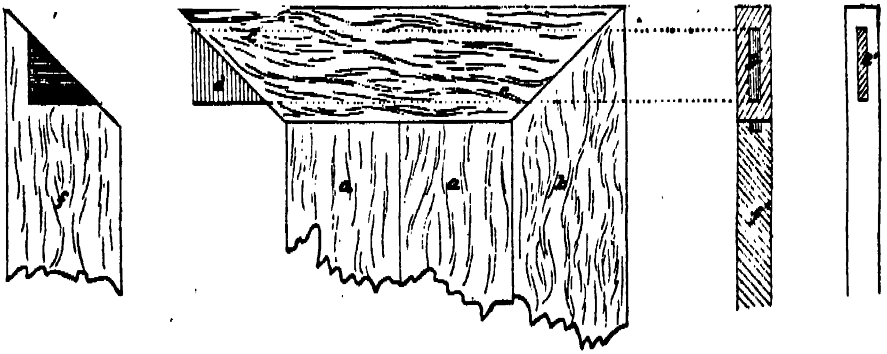

Fig. 11.

Joined Boards secured together with Cross Rails and Vertical Styles.

Another method of securing the boards together when placed edge to edge is illustrated in fig. 11. In this the boards, as *a a*, are enclosed within a species of framing with two side "styles," part of one of which is shown at *b b*, and a cross-piece or "rail" *c c* connecting these. The method of joining these two members will be described in a future chapter when we come to illustrate methods of joining pieces in different relations to each other, as pieces at right angles, shown in this diagram. The boards *a a* may simply be jammed tightly up against each other by the side styles *b b*; or better and more secure work will be obtained by ploughing the inside edges of the side styles, as *b b*, and the inner and lower edge of cross-piece *c c*; and finishing the outside edge of *a* and the upper ends of all the boards with a tongue; or all the members may be secured together, as at *e* and *g* in fig. 10. The boards, as *a a*, may either be brought up edge to edge with a plain joint, as in fig. 11, or the junction at edges may be finished to show as at *g h* in fig. 4, or as in figs. 5 and 7, *f* is the other style or side-piece corresponding to *b*, with upper part in section showing mortise at seat for tenon *d*.

As elsewhere stated, the joints of "joinery" and those of "carpentry" in several instances are so similar, at least in principle, if not in detail, and, so to say, overlap each other, that it is difficult to draw the line which separates them; the only practical difference between them being this, that joinery deals with small, carpentry with large masses or pieces of timber. Several of the joints illustrated in this paper are examples of this peculiarity, and a marked example of it will be found in the first paragraph of Chapter III.

THE COTTAGE AND THE VILLA GARDENER.

THE LEADING PRINCIPLES AND PRACTICE OF THE ART OF FAMILY GARDENING.

CHAPTER I.

Introductory.

IT may well be questioned whether, of all the arts which engage the attention and engross the cares of man in the present condition of society, there is one so popularly attractive as that of gardening. Nor need this be matter of surprise. For looking at the art in its twofold aspect—as ministering at once to that love of the beautiful in natural objects which all possess more or less, and to the utilities and necessities of life—we find that it yields in the largest degree satisfaction in both.

Gardening is essentially a healthy occupation. And we use this term as conveying much more than it is usually considered to convey,—as embracing considerations connected with a healthy moral tone, as well as a highly developed physical condition. For although, as in everything in which man is concerned, the taint of wrong-doing sullies and spoils the work, there is beyond all doubt an elevating tendency in the labours of the garden. So universally is this conceded, that though a good and worthy man may not be possessed of a great love of flowers, nor be much touched by the tender thoughts which their lovely tints and tones of colour, the elegance of their forms and the delightful odours they shed around, are so well calculated to inspire, yet no one doubts that if a man hitherto leading a degraded and degrading life, wedded to the evils which kill the mind as well as the body, once becomes, or should by some powerful moral motive become, a lover of and a cultivator of flowers—he will have at least a much better chance of getting freed from the bonds of a vicious life than if he lacked the love of, and did not give the needful care to, the cultivation of the products of the soil, at once lovely and useful as they are.

Healthy Moral Influence of Gardening.

For in such cases—which have, fortunately for society and infinitely more so for themselves, been by no means few in the experience of everyday life—it would be found, as many have found who have never been the bondsmen of the grosser vices of society, that such a keen interest in the occupation of the garden would spring up, such an earnest desire to persevere with its varied and ever interesting work, that the desire to give the necessary time to it would become a stronger incentive to action than that which might tempt them to go once more astray in the old walks of degrading vice. We do not say that this would at once be the case; but assuredly if a man began with even but a small degree of earnestness in the work of the garden, it would so rapidly grow in interest that he would be less and less inclined to leave it for accustomed haunts, even with all their powerful inducements to go astray from the paths which lead man to higher and purer life. We purposely cite this case, inasmuch as it affords evidence as striking as it is truthful of what we have advanced, that gardening is essentially a healthy occupation—healthy alike in promoting the moral as well as the physical condition of those who engage in it. Nor does the fact that there are exceptions to this, and that very good gardeners there are who are very worthless men, at all detract from or give denial to its truth; they only prove the rule. For in truth the work of gardening is a singularly fascinating one: so fascinating and engrossing in its varied cares, that those who have a strong natural love for its work seem to have this more and more strengthened the longer they occupy themselves with it, while in the case of those who have no well defined liking for it, but who have from one motive or another been induced even in late life to begin its work, it is found so attractive that they—very much to their own surprise, as we have known in more instances than one—get the more and more to like it the longer they keep doing its varied and ever varying work.

Gardening as an Industrial Art.—A Producer of Vegetable Food.

As to the value of gardening as one of the industrial arts which minister to the necessities of man, little need be said. Next to farming it is about the first essential in life, without which men could not live, and without which none of the arts could exist or flourish. The products of the vegetable and the market gardens have now become positive necessities of man's civilised condition; the want of which would create a wonderful difference in the way in which that existence or condition would be supported. And the same, although in a sense more or less modified, may be said of the fruit garden. And this latter, we may remark, is becoming more and more important as one of the factors in the sum of physical well-being. For the love of or the taste for fruit is becoming every year more and more developed. Nor must the fact be overlooked that the truth is becoming more accepted amongst all classes of society, that fruit exercises a remarkably beneficial influence on healthy physical development.

Gardening as Ministering to the Love of Flowers.

As to the fascination of the flower garden we need say but little. It is but few, we are happy to say, who are not delighted with the gifts of Flora. They possess more than one charm; for while they gratify the sense of sight by the variety and the beauty of their forms and the freshness of their foliage, they perhaps in even a much more touching and telling way minister to gratification by the sweetness of their odours—of which there is an endless number, with variations in delicacy as numerous. Many there are amongst us whose time occupied exclusively in business cares, or whose health prevents them from all exertion, who do not care much, if at all, for the labour of love which others devote so freely to flower culture and care; but there are few indeed who do not enjoy the sight of their well-stocked flower plots, or if they be not blessed with the actual possession of a garden, are not greatly gratified by the gift of a nosegay to grace the room of a wife or a daughter, or of a button bouquet to flourish in busy mart, lighten up some dingy office, or to show off "on 'Change." And it is gratifying to note that this love of flowers, so almost universally held by man, is becoming more and more extended; and, as in the case of the products of the fruit garden, so in this, it is becoming more and more conceded by all that flower cultivation is becoming an important factor in calculating the civilised condition of the community.

Doubtful whether we nationally make the most of Gardening as an Industrial Art.

It is very questionable, however, whether we make the most of gardening as an industrial art. Indeed, a closer survey of the actual condition existing amongst us would seem to indicate that it is not questionable at all, but that on the contrary we may at once decide that we do not. To keep for the present out of view consideration of localities in towns and their suburbs, and looking at what may be strictly regarded as rural districts, there are in those, pieces of land or extents of ground which, not at present availed of, indeed, not practically available, for farming purposes, could be used, and profitably, for gardens. Those as a rule would pay best if for raising vegetables. For them there is an ever increasing demand. It may, indeed, be said that the supply as a rule throughout the country has never been at all equal to it. We have never yet met with an instance in which, where additional gardens were opened, the products raised in them could not be sold. The more there is grown the more there is sold. Now, for these pieces of land for which there is at present no use—at least, no paying use—there could not be a better employment than their conversion into cottage gardens. From what we have already said, our readers will understand that in making this suggestion we have a double object in view; or rather, such an extension of cottage gardens which would flow from its adoption as would bring with it a double benefit. For while they would add largely to the supply of vegetables, and in the same degree add to the pecuniary resources of our cottagers, they would in large measure act as training schools, so to say, in which incentives to higher and purer life would be met with. As affording work for the head of the small household, they would be directly useful, while in great measure they would call up the help of the children. And even a very young boy or girl can do useful work in a well stocked and carefully cultivated garden to a much greater extent than most would be inclined to admit or believe who had no practical experience in this direction of household labour.

An Increase of Cottage Gardening an Important Social Question.

But apart altogether from the question of such an extension of cottage gardens, as affording a large supply of vegetables for the general market, the primary purpose they would serve as the gardens for the cottagers themselves is one of the most important in a social point of view. It is impossible to overestimate the value of a garden to a cottager. It helps to keep —and as a rule, with careful management, in many cases actually keeps—"the wolf from the door," as the saying is. A family supplying, or rather having the opportunity which a good garden affords to supply themselves with sundry vegetables, is rarely in want of the positive necessaries of life. For the mere refuse, or, as it is called, the waste of the garden, goes far to keep a pig; and much food, also otherwise useless, can be got for a small stock or "head" of poultry. And when, as assuredly will in time come about, the value of a "goat" for family purposes is as much appreciated as it is on the Continent, a garden would be found yielding much that would help to keep this the "poor man's cow." But much as is often really made of the cottage garden, and numerous as are the instances to be met with throughout the country in which the very most is made out of a tiny piece of land, it may with all safety be accepted as a truth that, as a rule, by no means is the most made of our cottage gardens. Let us glance at some of the points of this position.

Practical Points connected with Cottage Gardening.—Locality, Position, or Site in relation to the House or Cottage.

In the case of the cottage gardener little requires to be said as to *choice* of site or locality. This is a point which concerns him who has the means at command to purchase a place, or is so situated in life as to enable him to select his house, with its attached or connected garden, in the locality and in a position or site best suited to his tastes and notions of what a garden should be. But it does not concern the labouring man, whose gardening we are now briefly to consider in the light of the question, "how to make the most of it." In his case the choice of a garden is the one so well known as that which "Hobson," the innkeeper, gave to his customers in the matter of the horses they required, "this—or none." In other words, the labourer has no choice; he has to take what he can get, as he has generally to take in like fashion the cottage itself. And he should, and as a rule does, consider himself very fortunate indeed if he can get a cottage with a garden attached to or closely connected with it. So highly is a "bit of garden ground" valued, considered and let as part of the cottage, that not seldom do labourers rent cottages badly constructed and deficiently arranged, which they in other circumstances would not take, as being so very uncomfortable, simply because they consider the possession of the "bit of garden" attached to it of even greater importance to them than the cottage they live in. And so far as this latter is concerned, it may indeed be said with truth that, as a rule, in country and suburban districts, cottages are so badly constructed and so deficiently provided with accommodation, that it is a matter of very great difficulty for the labouring man to provide his family with one which only approaches—and that very remotely—the standard of a good, healthy, and convenient cottage. In this again it is "Hobson's choice." (See the papers entitled "The Sanitary Architect" and "The Domestic House Planner" for remarks on this subject.)

Practical Points of Cottage Gardening.—The Allotment System.

We have said that the value of the "bit of a garden" is all the more highly esteemed if it be in immediate contiguity to the cottage in which the labourer lives. There is very much more in this than appears at its first consideration. Infinitely better, no doubt, than having no garden at all, is the possession by the labourer of a small plot of "allotment garden," the locality of which is at some distance from his home. The allotment system is one which meets with the earnest approval of all those who are truly interested in the welfare of the labouring man, and who desire to place within his reach all means which will tend not merely to help him in his attempts to bring up his family comfortably, but those which will act as a powerful incentive in keeping him from attractions which only waste his means and ruin alike his health and prospects. But the allotment system, good as its influence is, is only at the best a makeshift, so to call it—a compromise between that which is desirable and that which can under the circumstances only be obtained.

One feature of the allotment system is that the ground or land on which its garden plots are, is situated in some defined locality. This may be nearer some cottages in which reside the labouring men who cultivate the allotment plots than is the case in others. But in relation to all of the cottages the allotment plots are situated at some distance—often at a considerable distance. To this rule there are but few exceptions; indeed, it can scarcely be otherwise, as the land for allotment gardens is not always easily to be obtained, and at the best it must, where choice is to be had, be placed so as to be nearest the greatest number of the cottages of those who cultivate its plots. Now, this distance, even when it is of the shortest, is a great drawback. A labouring man must indeed be either very fond of gardening, or be impelled by high motives of regard for and interest in the welfare of his family, who after a very hard day's work is induced, or feels inclined, to leave his cottage and walk over or along to his garden plot in the allotment ground. Those whose lines of life are "cast in more pleasant places" than are those of the labouring man have to ask themselves how they would feel and act if placed in those circumstances. And even in cases where the physical labour they have had to undertake in the conduct of their business is infinitely less than that of a labouring man, we are assured that after coming home from business they would feel as a rule so tired—and the jading feeling arising from the worry of business is often worse than the fatigue of physical exertion—that in nine cases out of ten they would make an excuse for not going to their garden work, if the garden lay even but across the road, or but a short distance along it.

The Allotment System of Cottage Gardening in its Working and Social Aspects.

This feature in a social point of view is very important, and as its importance takes hold of the public mind, so shall we see efforts in the right direction made. And that direction is easily enough found, for it lies in but one way—namely, that the garden should be part of the land on which the cottage stands. Numerous enough and powerful enough, in sad and sober truth, are the inducements or attractions held out to labouring men to leave the path of sobriety and prudent living. And it is, to say the least of it, scarcely wise if we lessen the power of the good influences which we can bring to bear upon him. Those good influences are unfortunately not so numerous as to justify easy laxity in their application; and of the few we have, the possession of a garden is one, perhaps, of the most powerful. For it appeals, as we have shown, to two strong motives for exertion in its work—the pleasure which the work itself gives, and the pecuniary advantages which flow from that work. When we know better than we do now what is due not merely to those who labour, but to those for whom the labour is done, we shall find it to be a rule that a garden closely attached to the cottage will be deemed an essential part of every labouring man's home. And this not merely in country places, but in the suburban districts of towns.

Time an Essential Element in the Economical Working of a Cottage Garden, frequently overlooked.—Importance of having the Garden adjoining or very near to the Cottage.

Although some may not think, or if thinking thereof will nevertheless not admit, that the time of the labouring man is of much or any value, it is worthy of note, however, that it is of just as great value to him, and has quite as high a proportion to his means and income, as the time of the busiest and best paid man in any class above him. And if one would but think of it, one would perceive that the hardness of the toil gone through by the labourer in his ordinary day's work makes the time he has to spare for himself all the more valuable. Assuredly we should not compel him to waste his time in any unnecessary exertion, especially in the doing of such work as is likely to elevate him morally and socially. Hence one reason why we insist upon the duty of those above him to give him his garden attached to his cottage. Another reason, and a specially good one, for securing this dual relationship between his house and his "bit of land" is one well known to every lover and practiser of gardening. And it lies in the fact that a very great deal of what may be called the minor work of cultivation, whether of flowers, fruit, or vegetables, can be done, and is done in individual cases, in the space of a very few minutes. We have said that this is the minor work of cultivation. But in view of the important and beneficial effect on the health of the plants which such minute cares exert, one is inclined to rank them as important as any other branch of work. Every one knows how in strolling through a garden, or in looking at plants in the conservatory or the sitting-room, with no idea of doing work—rather that of "musing" or amusing oneself—something attracts the eye in connection with a plant, and something done to it follows which the practised eye tells us should be done. And yet it is done in a minute or so, and thus without any seeming exertion. A great deal of useful work is thus effected, while all the while the matter is one of but amusement only. And yet every lover of plants knows well how kindly they take to such little gifts of attention, as if they loved to be attended to, and repay a thousandfold the little loving cares thus shown them. All observant lovers of plants and flowers will know well what we mean in saying all this, although to those who are not it may appear to be a "bit of romantic nonsense." Now, a labouring man who can by walking out of his cottage door reach in a step or two his tiny plots of garden—even if he goes out but to take his evening smoke or "look a bit about him," may be able to do many a kind office to his plants and flowers without much exertion. And if he likes his garden he will be certain to do these kind offices. Indeed, we are not sure but this doing of little things in gardens constitutes one of the highest pleasures of their work. It seems to bring one in such close relationship with individual plants and flowers, that a love for each as if each were a personality, a "living, loving thing," arises in the mind. Here again, to those who are not lovers of plants and flowers we shall seem to be but "talking nonsense."

System and Order in working the Cottage Garden Essential Elements in Success.

But if spare moments of time can be thus made useful, and highly so, it is, from what we have said of the value of time to the labourer, essential that he should make the most and the best of it. And he can only do this by having "order and method" in all he does. And if he attends to these—or rather this, for they are one and the same thing—he will be sure to economise his time to the utmost. Order admits of no waste—is indeed, as we have said, the truest preventive of it. If what may be called "odds and ends" of work constitute, as we have seen, one department of the labours of the garden, another, and the most important department, is made up of continuous and regular work. Each set of plants has its season; and each, therefore, must have its preparatory work done in due time, so that the season may be met: otherwise it is lost. And although there are some plants which offer facilities for thriving more than one season in the same year, there are others for which there is only one season in the whole year. This it is which makes gardening and farming alike essentially different from the great majority of other industrial pursuits; for while in those, if through laziness, indifference, or positive and wilful neglect, an opportunity of doing a piece of work be lost, there is nothing in the circumstances to prevent that work being done immediately after the folly of the first waste of time has been perpetrated. But in the farm and the garden, if a season be lost, one has to wait for a whole year before another opportunity is had to retrieve the error. In fact, it can never be retrieved; it is the gain of well done work utterly lost. A loss of this kind in other classes of work may be actually made up by extra work, by "stealing an hour from the night"; but there is no resource of this kind to the gardener who loses a season in certain crops. In other crops, as we have said, there is more than one season during the year; these can be cultivated in a succession of crops. Thus one may have more than one crop of turnips in the same year. Still, if one of the chances be lost, the rule named above holds good, and practically a season lost can never be made up for. Hence the labouring or cottage gardener portions out his work in due order, and it must be begun, too, at the proper time, and carried out till it is completed. Half-done work in gardening may as well be let alone, for it has no claim to be considered good work at all, and will yield little—not even half a crop.

THE ORNAMENTAL DRAUGHTSMAN:

HIS STUDY AND THE DETAILS OF ITS PRACTICE, CHIEFLY IN RELATION TO TECHNICAL WORK IN MANUFACTURING DESIGN.

CHAPTER IV.

AT the end of last chapter we made a few remarks on the importance of the student attending to the simple subjects we had there given. In all seriousness we advise the pupil not to leave this first series of lessons for the next until he has mastered them thoroughly. Let him bear in mind the lesson conveyed in the adage, "Fear in argument the man of one book." Equally may he fear in execution the man of one accomplishment. The great ornamental draughtsman, simply as such, is he who can draw perfectly straight and curved lines, and both of them equally well.

The student will at once perceive the object of these illustrations now to be given. They are intended to give examples of *curved lines*, and examples likewise of *straight and curved lines combined*, just as the previous figures commenced with straight lines. The first figures, he will notice, are of the simplest character. They gradually assume greater complexity, until, in the last, he has examples of no ordinary difficulty set him. Observe how almost imperceptibly such difficulty increases from figure to figure, the intention of which slow development he will of course, or should, understand.

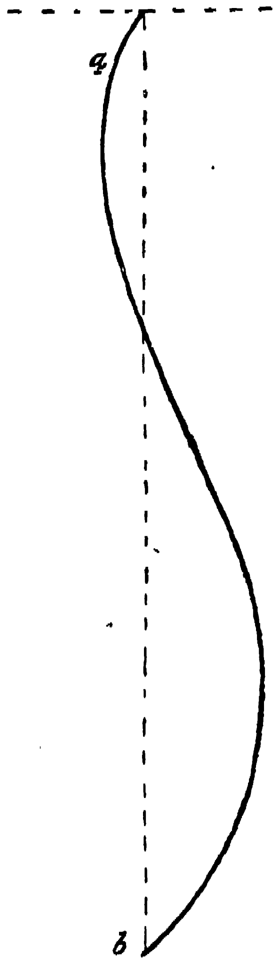

Fig. 18.

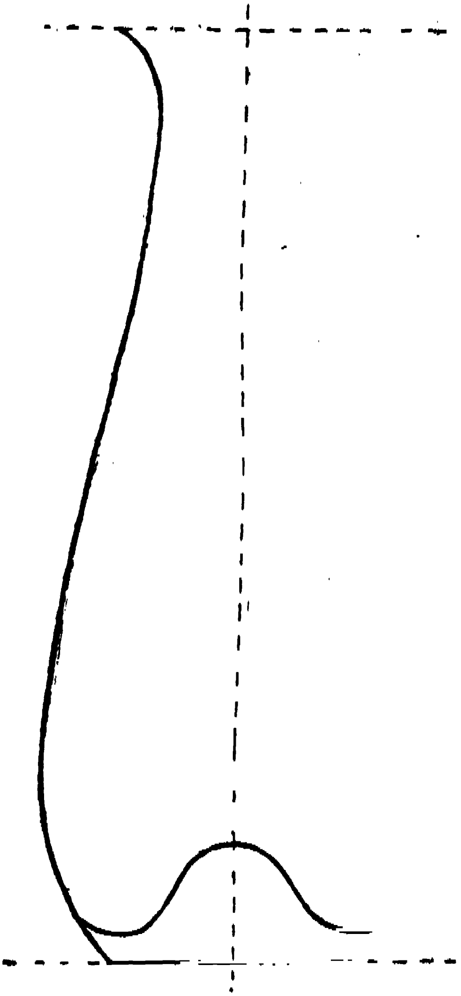

Fig. 19.

Lessons in the Drawing or the Copying of Curved Lines—Some Considerations connected with them.

In the preceding paragraphs we gave various lessons in the drawing of straight lines, and illustrations of their application to the simpler forms of ornamentation in different known and accepted "styles," by which name the various classes are distinguished. We now take up the department of "curved" lines; and in this, as in the simpler lessons of the earliest stages in the art, we would impress upon the pupil the importance of mastering each lesson thoroughly before he proceeds to the succeeding one. Hastily done is almost certain to be badly done work, and he must have a strangely constituted mind who would look upon this as the desired-for result of any labour. The Romans had a proverb which somewhat paradoxically declared that progress was all the quicker the slower it was made. The same lesson is taught us in our own proverb, "Slow and sure," or "Slow and steady wins the day." And the lesson these sayings teach us, as well as the experience of all who have succeeded in life—of which, indeed, those proverbs are but the concrete experience, embodying, as so many of our proverbs do, the wisdom of ages or generations—is simply this, that patient work is necessary to the accomplishment of good work. And the more that patience is exercised, and the longer, therefore, the time taken in learning to do work *well*, the greater is the facility with which the good work is done, and in proportion the less demand there is made for the exercise of patience and the outlay of time. It is thus, and only thus, that true dexterity in the doing of any work is obtained. And in this truth the pupil should take comfort, if comfort he needs, in view of what claim work will make upon him for patience in learning to do it well. For he will find that each step carefully and firmly taken will give him precisely the strength he requires to take the next and more difficult one. The young blacksmith's arm becomes the stronger the more he wields the heavy iron hammer, till at last it becomes as if its muscles were themselves bars or rods of iron, capable of showering down blows fierce and long, sustained in a way which he himself in his beginnings could scarcely have believed possible. So in like manner, although his work is as delicate as that of the other is forcible, will the young draughtsman find that the longer he practises in the right way, the easier will his practice become, till at last he becomes a "deft and clever workman, worthy of his work and of his hire." We say, in the "right way," for if not, progress is just so much time wasted, leading him, as every step of it must lead him, farther and farther away from the point he wishes so much to reach. The art of the ornamental draughtsman, like every other work to be done, has its apprentice period, and if the pupil earnestly make up his mind to face what is called the "drudgery of 'prentice life," with a determination to do it cheerfully and well, he will find that it is no drudgery at all, but a mere necessity of the work—as little to be called drudgery, seeing it is the very basis of all higher work, as the foundation of a building is to be pronounced unnecessary or useless, since it is out of sight and is the first part of the work which has been done.

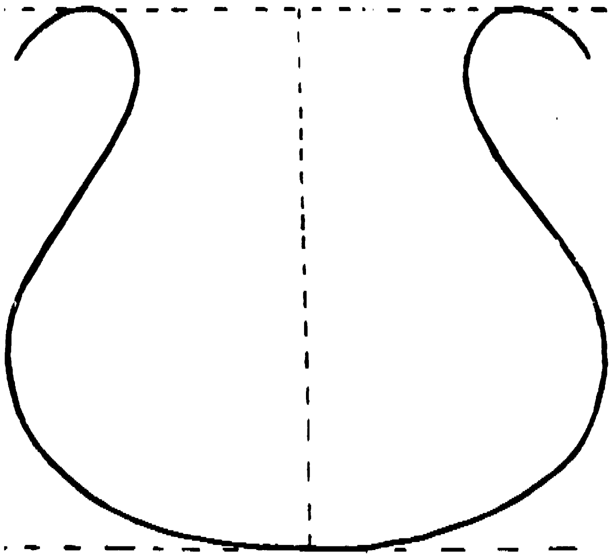

Fig. 20.

Such considerations, and the thoughts to which they ought to give rise, are of the utmost value to the art pupil. We do not for a moment conceive that any of our readers have that unfortunate constitution of mind we have alluded to, which permits them willingly to accept of bad work as a necessary result of labour, or to be satisfied with it when it is done. Few indeed have their judgment so warped or their minds so filed ("For Banquo's issue have I *filed* my mind"—Shakespeare in *Macbeth*) as this. Still one may have his *morale* not thus debased, indeed, have it high and pure, and yet be tempted, in his haste to be a successful ornamental draughtsman, to overlook or overrun those wise and prudent precautions by which alone success can be won. What, however, we have here and elsewhere said, should be enough to show him how this danger can be avoided; and avoid it he must if he wishes to be a successful and useful draughtsman. For success now-a-days more than ever is only measured by the extent of its utility.

First Lesson in the Drawing or the Copying of Curved Lines.

In commencing our lessons on curved lines, let us take fig. 18 in hand. One simple-looking curve enough here, certainly: as simple as the pot-hooks and hangers of our schooldays. But in no wise will it be prudent for the young ornamental draughtsman to regard them as so easy of imitation that he may sensibly "slur" over them. His experience of the subjects in figs. 1 to 6 (straight lines) will have given him some notion of the difficulty of copying seemingly "simple" examples; and it is therefore, we hope, unnecessary to caution him here against shirking the faithful drawing of what we place before him in this figure.

With great care, then, let him try to copy the curve in fig. 18, starting at *a*. Set about the work slowly. "Do not fancy"—let us say to him—"that you draw that curve with a dash of the pencil, like the pen-and-ink flourish of a writing-master. The figure you are copying was not drawn so. Keep the whole bend of the line in your eye, and as you deliberately progress towards *b* compare strictly what you are doing with the beginning of the curve, as well as with the original." It is absolutely certain, though, despite all his pains, that his first copy will not bear for a moment the severe scrutiny to which, in accordance with the instructions given concerning figs. 1 to 6, it will be subjected. But the habit of dogged perseverance, which frowns down all difficulties and tramples down all obstacles, will soon teach him the direction in which success lies. It has been said by a deep thinker that "there is no such thing in this universe as genius, in the common acceptation of the word. Profound skill in anything is impossible without downright hard work. The philosophy on this matter is synonymous with that of one who said, 'Genius is the transcendent power of taking trouble.'"

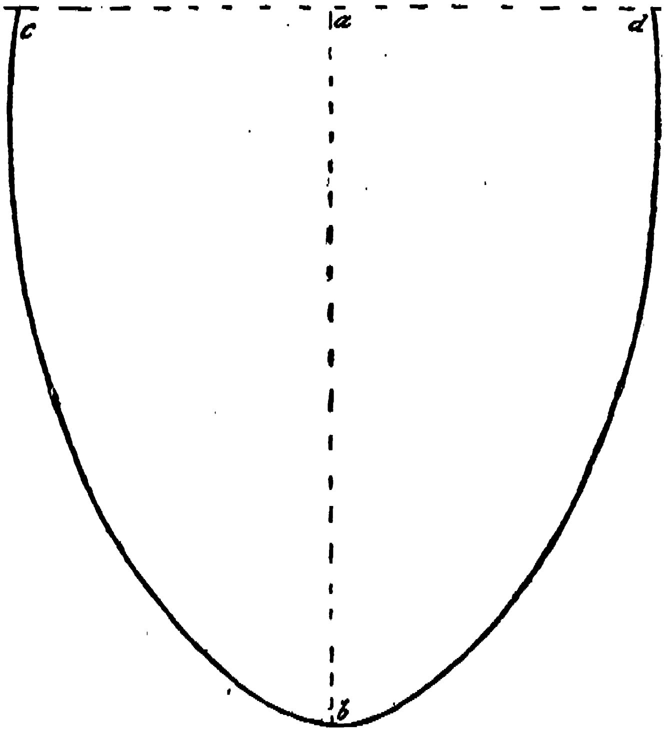

Fig. 21.

Second Lesson in the Drawing or the Copying of Curved Lines.

The curves in fig. 19 the young ornamental draughtsman will draw and criticise after the same fashion, remembering, however, to begin at the top; figs. 18 and 19 being formed on exactly the same principle, and being, in a measure, the same curves, but standing differently related to the edge of the sheet. Fig. 20 is a lesson on the same direction of curve as in fig. 18, and the lines of it are related to each other as in fig. 19, but joined at foot by a convex curved line as shown. The dotted lines in these three figures, as also in figs. 21 and 22, show how straight lines may be put in by which the pupil may, as it were, "chalk" out the leading lengths, etc., of the curved lines. These test lines, as they may be called, are of course to be put in, in the lightest pencil line, and their relations to each other must in all cases be decided by the eye. This accurate estimation of lengths or spaces is one of the things first to be learned by the pupil. But upon this point we have already enlarged.

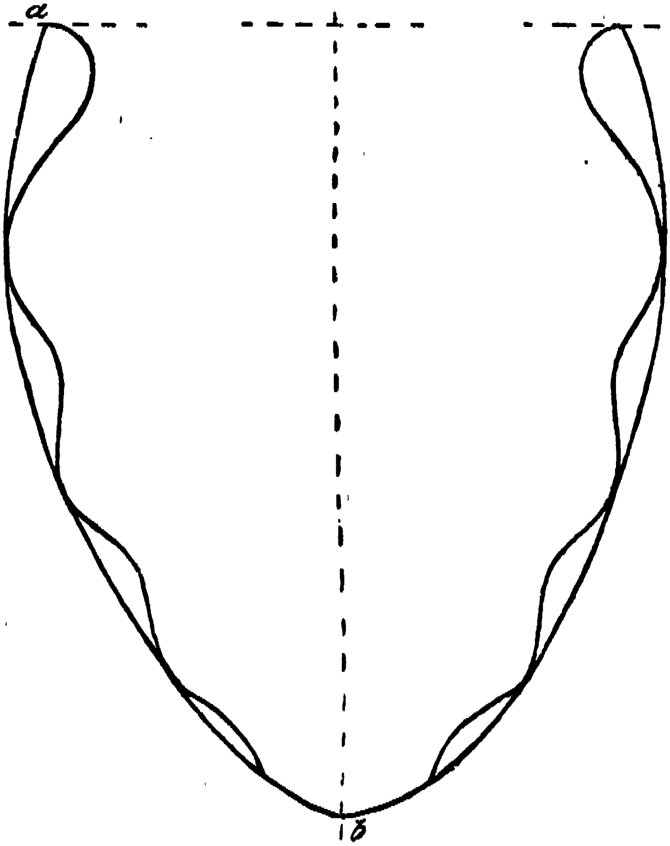

Fig. 22.

Third Lesson in the Drawing or the Copying of Curved Lines.

Fig. 21 is an illustration of a different order of curved line. In copying this the pupil should first draw a light line corresponding to the dotted line *a b*; and on this, estimating with the eye as accurately as he can, giving to the depth *a b* of the figure, the distance *b a*—and through point *a*, of course at right angles (see the paper "The Geometrical Draughtsman") to *a b*, draw a line *c d*, estimating, again by the eye alone, the width of the curve or figure at top; half of this is set off, on each side equally of the point *a*, to *c* and *d*. The pupil is now prepared to put in the curves. The first put in is that to the left hand, beginning at the upper left-hand corner *c*, and drawing to the point *b*. This being done, he puts the right-hand curved line in by drawing from upper right-hand corner *d* to the point *b*, making the curve to match precisely the other. After he has finished he must conscientiously examine his copy, not merely with a view to test the accuracy of his curved lines, but that of the distances which give what is called the size or dimensions of the drawing. The pupil should copy fig. 22 in the same manner, observing that the lines incline inward a little more at the top than fig. 21. Now let him proceed at the top left-hand corner, *a*, to draw the waving or wavy line down to the bottom, *b*, and make the right-hand side to match it; and then carefully examine the drawings and see that they are like the copies. The draughtsman must not be satisfied if they *look* like the originals: they *must be* absolutely the same.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER III.

Thickening Pastes (*continued*).

Extract Paste.—This is a mixture of gum dragon, starch, acetic acid, and oil. The ingredients must be very well boiled. The following are the usual proportions: three gallons of water, three gallons of 1 lb. per gallon solution of gum dragon, three gallons of acetic acid or good vinegar, 12 lb. starch, and three gallons of rape or olive oil. After boiling, the mixture is cooled and then strained, when it is ready for use. As its name implies, it is used solely for thickening alizarine extract colours.

Pigment pastes are generally composed of a mixture of kid glue and starch, to which a little oil, turpentine, and glycerine are usually added. The ordinary strength is 4½ lb. glue and 1 lb. wheaten starch per gallon. One part of a paste of 9 lb. glue per gallon is boiled together with one part water and 1 lb. starch per gallon. After boiling, the oil, turpentine and glycerine are added in small but variable proportions. The latter three constituents are added to prevent frothing in printing. This mixture is chiefly used in pigment colours along with albumen.

2. Thickened Mordant Pastes.

Tannic paste is a mixture of starch and tannic acid, generally with the addition of acetic acid. It is usual for convenience' sake to have two strengths of this paste—one being 1 lb. of tannic acid, 1 lb. starch, and 1 pint acetic acid, at 8° Tw.; and the other 2 lb. tannic acid, and same quantities starch and acetic acid. The ingredients are simply boiled all together till the starch thickens, and used cold. It is employed for mixing the aniline colours.

Acetate of alumina paste for certain aniline colours that are fixed with alumina, and for a number of other colours. It is prepared by thickening acetate of alumina liquor, at about 12° Tw., with 1 lb. starch per gallon; the paste thus obtained is cooled, and 1 gallon of a cold solution of 6 lb. of white arsenic per gallon of glycerine added for every 20 gallons of paste made. The arsenic standard is prepared by boiling the arsenic and glycerine together for several hours, and decanting it from any sediment that may remain. Solution of borax may be substituted, but disadvantageously, for the glycerine. It is usual to have at least two different alumina pastes: 1st, one consisting of the above paste, and used for strong colours—*i.e.* for deep shades of colour; and 2nd, this same paste reduced to half strength by mixing with an equal quantity of starch paste, and used for light shades of colour in which less mordant is required.

Having now mentioned the most generally used pastes containing thickening and mordant, we next proceed to treat of the chief standard pastes ready for printing, or in print-works language "colours," —consisting either of thickened mordant alone or mordant and colouring matter.

3. Thickened Mordants for Dyeing.

The thickened mordant is printed on the cloth, and the cloth undergoes the dyeing process—the dye fixing itself only upon the mordanted parts, thus bringing out the design or pattern.

1. *Alizarine Reds.*—Many receipts are in vogue for making mordant pastes for alizarine red and pink; but that we now give has been very extensively adopted, and, provided the red liquor be of the best quality, yields as good a red or pink as can be obtained. One part of red liquor at 12° Tw. to 2½ water, and mix with 1½ lb. of flour per gallon. Boil, and when nearly cold add 1 oz. of tin crystals per gallon. For the convenience of the printer, to enable him to see the impression, it is usual to add to the above a little magenta solution or Persian berry liquor. From this standard paste different reductions or degrees of dilution are made with starch paste and water, according to the depth of shade up to which it is wanted to dye the pattern. For pinks aluminate of soda is frequently used instead of red liquor (see further on).

2. *Madder Black Mordant.*—This is simply acetate of iron liquor at 8° Tw., thickened with a mixture of starch and British gum.

3. *Madder or Alizarine Purple or Lilac Mordant.*—For light shades 23 gallons of water and 36 lb. of flour are thoroughly mixed and boiled; 1 gallon of solution of arsenic in caustic soda, 1 gallon of acetic acid, and 1 gallon of iron liquor at 24° Tw. are then added. For dark shades 12 gallons of the above, 10 gills of water, and 1 gill of iron liquor.

4. *Alizarine Chocolate Mordants.*—These consist of mixtures of iron liquor and red liquor in varying proportions. The following gives an average colour —Six parts red liquor and one part iron liquor, both at 24° Tw., reduced with water and thickened with flour, according to the shade which it is required the dyed goods should be.

5. *Mordants for Aniline Colours, Persian Berries, etc.*, are also made from red liquor. An ordinary shade would be red liquor at 6° Tw., thickened with flour. This mordant paste is used for dyeing aniline greens, blues, and violets; the paste is printed on, and dyed up in a tannin solution, and then in the solution of the dye. Tannic acid paste made as described above is also used for dyeing many aniline dyes; but in this case it is necessary that the cloth, after printing, should be passed through a bath of solution of tartar emetic (about 1 to 2 oz. per gallon),

so that where the latter is not admissible, or injurious to some other colour of the pattern, the alumina mordant is used; whilst if greater fastness is required tannic acid mordant must be used. 1 lb. per gallon of pure tannic acid dyes up deep shades of aniline greens and violet, methylene blue, and auramine.

6. *Catechu Mordants.*—These are principally for dyeing with the dye-woods—such as peachwood, bark, sumac, and also for garancine; various mixtures of these being generally used according to the shade required. The following example will give the reader an idea of the general composition of catechu mordants:—Take 1 lb. of catechu, boil in 1 gallon of water, add 1 lb. of sal-ammoniac, 1 pint of acetic acid, and $\frac{1}{32}$nd part nitrate of copper, and thicken with starch. This is printed on and dyed-up in the usual way.

4. Thickened Pastes containing Colouring Matter as well as Mordant.

1. *Alizarine Colours, or "Extract Red Colours."*—The preparation of these colours, made from alizarine paste, requires the utmost care. Few colours demand more attention to cleanliness in their preparation than those of alizarine extract. It need only be remembered that alizarine yields with iron a chocolate or other dark shade, and that there is scarcely a more widely distributed substance than iron—that it exists alike in the earth, in the materials of buildings, and in dust—to see how necessary for the production of a pure red colour to exclude the dust that flies about the colour shop, dirt from the colour-mixer's hands, or from colour-tubs, etc. For the same reason the drugs used in mixing these colours should be as pure as can be obtained; especially should there be absence of traces of iron, copper, and lead. Extract colours should always be as freshly prepared as possible, and made only in such quantities as are required, from time to time, as they are rapidly injured by exposure to air. There are, of course, extract colours of all strengths, according to the shade required: an average colour consists of 6 parts of alizarine paste, 10%, mixed cold with 14 parts extract paste (already given), 1 part acetate of lime and 1½ part sulphocyanide of alumina, both at 12° Tw., when it is ready for immediate printing. This important subject of alizarine red and pink colours will be treated more in detail in a subsequent paper. *Chocolates* are made from the above by the addition of varying amounts of iron liquor. *Purples* are likewise prepared from them, by the addition of different quantities of aniline-violet solution and iron liquor. There are many intermediate colours and shades of colours, which the experience of the colour shop alone can impart to the reader. It may be mentioned that waste extract red colour, *i.e.* the residues from colour-boxes, etc., are all thrown into a cask and kept to make dark shades of maroons, chocolates, etc., by addition of iron liquor.

2. *The Aniline Colours.*—Most of the "aniline" dyes now in use are fixed either with tannic acid or acetate of alumina; the former method yields as a rule faster, but less brilliant shades. As already mentioned, the aniline colours that are fixed by means of tannic acid are prepared from a standard "tannic acid paste." A standard of the anilino dye also is generally kept in stock, say 8 or 10 oz. of dye per gallon of acetic acid at 4° Tw. For example, to give a moderate shade of aniline green, 1½ gill of an 8 oz. standard of green is mixed with 14½ gills tannic acid paste (containing 1 lb. tannic acid per gallon) in the cold, the colour is then strained, and is ready for printing. This gives a colour which thus contains ¾ oz. of aniline green per gallon. The other aniline colours are mixed in a similar manner. As an example of the anilines fixed with alumina may be given saffranine. In this case the proper quantity of saffranine standard, or rose, is mixed cold with acetate of alumina paste. An average shade is obtained from 1 gill of 8 oz. standard per gallon of paste.

3. *Pigment Colours.*—These, as the reader will be aware, are colours which are applied to the cloth in an insoluble state; and after they are printed on are made to adhere to the cloth mechanically. To effect this a chemical process really takes place. Pigment colours are always used in a state of fine division, mixed with solution of albumen, and printed on the calico, which is then steamed, by which means the albumen becomes insoluble, or coagulates, and firmly adheres to the cloth and retains fast hold of the colour. In the colour shop the pigment is mixed intimately with the solution of albumen, the latter being added gradually until the whole is of uniform consistence, and then well strained. In many cases it is convenient to keep a strong standard of the colour ready mixed with the albumen, so that in making a colour of that pigment it is only necessary to measure standard and thickening; this saves much time and labour. Of course some other substances are used along with albumen, such as gum dragon, gum Senegal, and pigment paste, as before mentioned; but this does not affect the method of mixing, nor the manner of fixing, by subjecting the printed cloth to the action of steam.

4. *Vegetable Colours.*—Few vegetable dyes are now used in the colour shop. Most of those upon which both dying and printing may be said to have chiefly depended a few years ago have been since then superseded by artificially produced dyes.

ORNAMENTAL WORK IN MOULDINGS.

(BEING ONE OF THE SUB-SECTIONS OF "FORM AND COLOUR IN INDUSTRIAL DECORATION.")

CHAPTER I.

Introductory.—Beauty in Form.

In the series of chapters given under the heading of "Form and Colour in Industrial Decoration," "The Ornamental Draughtsman," and "The Cabinet Maker," the reader will find some remarks on the general subject of Design. This term is commonly employed to convey the idea that in anything which is constructed or made, the principal motive for and ultimate object of which is to subserve some purpose of obvious utility, there is something added to or superimposed upon the materials which in the aggregate form the object constructed. This addition has for its direct and some say its only object, to please the eye, or as others express it, to gratify the taste. In other words, while the main object or body depends upon the rules and principles of construction, this added quality comes within the domain of what is now so frequently talked of—namely, æsthetics. The necessities of the case compel, as it were, the definition we have here given; but on consideration, and as will be fully illustrated hereafter, it will been seen that this quality in an object which pleases the eye or gratifies the taste does not always result from, or is not always created by something which is added to a constructed body. For that body in itself, that is, in its lines as taken in by the eye, may present the quality we have named; and the mere looking at it will give that pleasure or gratification to which we have alluded. This may be very familiarly illustrated by a jug or vessel to contain liquid. This article primarily comes under the designation or class of a constructed article specially made. And it may be so made that it will completely enongh serve its main object—namely, to hold or contain a certain quantity or volume of water, so that it may be confined and be carried from place to place. But this enclosing or containing space of the jug or vessel may be of any shape, and this internal shape may—and as a general rule does—give the external shape or outline, or what in the language of technical design is called its configuration or form. But this may be such that it does not please the eye when looked at; in other and ordinary words, it is "ugly," and this in various degrees, from the state or condition which men say is "endurable" to that which is strongly denounced as "hideous." But it is also as obvious that the shape, outline, configuration, or form may be such that every line which gives this is in itself pleasing to the eye, and the whole or aggregate gives an object to which the term "beautiful" is applied. This sense or appreciation of what in the simplest language (which at this stage of our paper we purposely use) may be called "the look of the thing" or object, seems to come instinctively or intuitively to men. Even although what is called, for lack of a better and more specially distinctive term, "taste" may not be cultivated, one can tell at a glance that one form or shape is what they say is "ugly"—that is, that it does not please the eye or the mind, or rather both; and that another form or shape is pronounced to be "beautiful"—that is, that it is pleasant to be "looked" at. But while as a rule this is true of most men, they cannot with equal facility state explicitly why they pronounce or give their reasons for deciding one form to be ugly, the other beautiful.

Difficulty in defining what is Beautiful.

Nor do those who offer no pretence, even of the slightest, to the possession of what is cultivated taste, stand alone in this inability to give a reason for their believing one thing to be beautiful when looked at, another the reverse of this. For even those who do not require to pretend to the possession of cultivated taste, but who have it, are by no means able to give an explanation of what in reality distinguishes the beautiful. No two are found to agree upon a definition of the term "beauty." Nor is the reason for this indecision or incertitude far to seek. It finds expression in the common saying "tastes differ." And beyond what this saying leads to we cannot in reality go. For what appears to one eye pleasing is to another anything but this; so that opinion as to the beauty of a thing ranges through a series of gradations as numerous as the individuals who may be exercising and expressing their opinion about it. But while this diversity of opinion exists as to a specific definition of the term "beauty" or "beautiful," or this inability on the part of most of us to give a reason why we think the "look" of a thing as this or as that, there is, fortunately for the Ornamental Designer, a very decided agreement amongst all varieties of men thus far. Namely, that there is such a marked distinction between forms, shapes, or outlines which objects possess, that certain of them are pronounced without hesitation to be ugly—that is, not pleasing to the taste: instinctively men know them to be such—while others, on the contrary, are said to be, if not beautiful, taking their own notions as the basis of their definition of the term, certainly not unpleasing to them. Take any object, and ninety-nine out of a hundred who are looking at it will pronounce it to be "pleasing," to be "nice to look at," to "gratify the taste," to be "pretty," to be "beautiful," to be "æsthetic." All these modes of expression convey in reality the same meaning, and that, more by way of having a definite name than from any agreement that it means a definite quality, men have agreed to call by the name of "beauty" or say that the thing is "beautiful." Even the one hundredth, who may stare stolidly at the object which calls forth a decided expression of some opinion from his ninety-nine fellows, and be quite incapable to find a word or words to convey the fact that the object has made any impression on his mind—should he possess this, which is under the circumstances doubtful—feels nevertheless a something, to which if he could give a name it might find a positive expression in one of the terms above used, that it was "nice to look at"—probably qualifying this with "enough"—"nice enough," or more negatively by "It ain't ugly," or, "It's good enough."

"Æsthetic," a Term used in connection with Artistic Industrial Decoration.

We have used the words "taste," "æsthetic," "look," "form," "design": it will be well to examine these, as we may from their inner meaning arrive at something definite as to the ideas they convey, and thus they may be useful in making clear sundry practical points of some value in connection with the important subject which will for some chapters engage our attention. One of those words just named is at present used everywhere, and as we might say at all times, whether or no it be the fact that those times are always appropriate. The word which is, in fact, while we write, a popular "rage," or "craze," is "æsthetic." When many use the common phrase the "look" of a thing, those who indulge in nothing that is to their mind common, and are always mouthing about things being "æsthetic," little think that the commoner, or as they will probably term it the "vulgar" expression, and the much grander sounding, or in their language "muchly fine" one, mean precisely the same thing—that is, if they will admit that words have a meaning, which from some they use plain people would be apt to decide that they think they have not. The term "æsthetics," then, is derived from the Greek word *αισθετικός* (*aisthetikos*), and this from *αισθάνομαι*, to perceive. This word again comes from the Latin words *per*, by, and *capere*, to take, receive or obtain. And this taking or reception is effected through the medium of the senses. By the sense of seeing we perceive what an object is; we have or obtain the perception of the "see-able" peculiarities of an object. In other and plain language we look at it, and from or by the sense of seeing we have a perception of what we call the "look of the thing." Thus the external peculiarities of an object are those which can be seen, so that æsthetics may be defined as the science of looking at objects, or that connected with the look of things. As plain language is not generally considered dignified enough to be applied to a science, æsthetics is therefore defined to be the "science of the beautiful in nature and in art," or as some prefer to call it, with a happy combination of the common and the dignified form of words, the "science of taste."

The compilers of some, we might say not a few of the older, or shall we say the very oldest of dictionaries, had a method of considerably lightening the labour of their drudgery (by the way, it is worthy of noting here that the grandest and most honest of the fraternity, brave old Samuel Johnson, gave as one of the definitions of a "drudge," the "compiler of a dictionary") by printing after a word of which they themselves did not know the meaning, "See so-and-so," and when you referred to so-and-so, the same formula was repeated and you were sent back to the point you came from. This see-saw "so-and-so" system, although mighty convenient for either the ignorant or the lazy lexicographer, was anything but so to the thirster after knowledge of words. We in this case do not intend to imitate the old compilers—by saying "Æsthetics—see Taste"—and at "Taste," "see Æsthetics." We have given as one of the definitions of æsthetics that it is the science, or philosophy, of taste. Now, what is taste? This word is derived, according to some, from the French *tater*, to feel; to others, from the Norman-French *taster*, to try, and means to perceive a thing, not, as already stated, by the medium of the sense of seeing, in which the eye is the power, but by that of the palate, in which the tongue is the power. In common language, the perception (see the last paragraph on æsthetics) of the qualities of an object through the medium of the tongue is called "tasting a thing," just as the perception of the qualities of an object through the medium of the eye is, as we have seen, the "looking at a thing." But how comes it, the reader may ask, that if all this be—and it is—so, the term taste is so applied, that æsthetics is defined to be the science of taste? What has æsthetics to do with eating, the refined to do with the vulgar? Some who are sarcastically inclined might find an answer to the question in this fashion. Man has been defined in divers ways; amongst others he is said to be a "cooking," and therefore "an eating animal." For the only object of cooking is to eat what is cooked. And as a man must eat to live, eating, whether he "cook" or not—for he may eat things as he gets them from nature (hence, by the way, the French term *au naturelle*, without any cooking additions, as sauces or the like, at all)—is therefore the primary, the essential work of life. When he eats he tastes: with cooks tasting is an essential part of their art, and the terms indeed are often taken to mean the same thing. And we can conceive of a state of early society when eating was the main, the only object, of living; for a man would only work that he might get something to eat—what he would call his "living"—the only thing, in point of fact, which constituted life in those, the dark ages. In this bygone condition of society a man of great experience in eating would therefore be called a "man of taste,"—and the expression would be from generation to generation handed down to modern—which, of course, being, as some at least say, refined times, the ideas conveyed by the term "taste" only have relation, not to the vulgar act of eating, but to the higher things in nature and art. Thus the science of taste would *par excellence* be so confined, having nothing to do with taste in its literal meaning, in which the tongue only was concerned. This may or may not be the way, according to our assumed sarcastical authority, in which the word taste has got to have such a very limited meaning; so that the high compliment paid now-a-days to one who is said to be a "man of taste," has quite another meaning from that which it had in the old vulgar times when eating and therefore tasting was the great object of life. Hence it may have come about that just as eating, being the highest object of material life, was called taste, so those who deemed that contemplation of the beautiful in nature and in art was the highest object of intellectual life would appropriate the distinctive term. The great probability is, however, that such is the derivation or origin of the term. Be all this as it may, and however it came about, the term "taste" now refers, and almost wholly refers, to the cultivation of the beautiful in art and in nature; although, adhering to its derivation, taste literally means the perception of a thing through the medium of the tongue.

"Beauty," "The Beautiful"—Terms used.—Derivation.

But accepting this more remote and restricted meaning of the term taste as concerned only with matters of the beautiful, we still are met with the question, What is the beautiful?—one which we have seen, not only from what has been said in this, but in the chapters entitled "The Ornamental Draughtsman," has as yet received no precise definition accepted by all. Looking also in this instance at the inner meaning of the term, we find that the word "beauty" is directly derived from the French *beauté*, from *beau*, good or fine, and this again is based on the Latin *bonus*, good. To beauti*fy* is to make a thing good, from the above French word *beauté*, and the Latin verb *facere*, to make. A beautiful thing is therefore that which is *made* beautiful either by nature or by art; and although literally meaning goodness, beauty is defined with general acceptance as signifying that which possesses properties which please the eye or gratify the mind—but another way of stating that the thing is good. Now, what is good in this sense in the eyes of one may not appear to be so in those of another. Hence the diversity of opinion as to what is beautiful and what is not. So that the position is just this: that in any art which attempts to *make* (see above as to "beautify") a thing beautiful, the decision as to the result will be altogether determined by what the individual or the artist deems to be good—that is, derived from and influenced by his ideas of what beauty is, or what constitutes the beautiful.

And this estimate of beauty which the individual forms must be based on the results of his observation. He himself may aver that his estimate of what constitutes the beautiful is derived from or based upon some theory of his own, more or less metaphysical; but it will nevertheless be found, in tracing the matter up to its source, that it is really based upon observation of objects around him. This observation may be partial and defective, or it may be full and accurate; but whether the one or the other, it is that which supplies him with the material, so to say, by the use of which he gives expression to his work, of whatever kind it be, of *making* a thing *beautiful*. And this work will be beautiful to a class either numerous or the reverse in strict proportion to the width and fulness of the range of his observation, and upon which he founds his conception of what is the beautiful. The artist, like any one imparting, can only give what he has got; and in this matter what he himself possesses is dependent largely upon the way in which he has availed himself of the stores, so to call them, of the beautiful at his command. And beautiful things, acknowledged by all to be such, abound in widest diversity of endless profusion all around him, both in the productions of nature and of art. Chiefly, however, in the former; indeed, we may say wholly, for all true beauty in art is derived from a just conception of the beauties of nature, for it is in nature that all forms exist. Her combinations of those are as endless, as the fields in which they are presented are widely spread and numerous. Whatever be the results of the lessons one receives in art, the teacher, in the first instance, must be and always is nature. This does not preclude, on the contrary it invites, attention to the teachings of art; and all high art admitted to be so on all sides is based upon the teachings of nature.

Endless Diversity of Form in Natural Objects.

We say that the forms found in nature are endless; so also are the combinations of those elements of what is beautiful in nature and in art. The colours in which those forms are, so to say, draped or clothed, are also endless in their variety and in their combinations.

It is with form, however, that the ornamental designer has to do. And the form or shape, or external appearance presented by the object, is made up wholly of lines. And whatever may be the characteristics of the surface of the body, whether it be flat or rounded, or whether in either of those cases the flat or rounded surface be left smooth, or whether it be cut up into hollows of diverse kinds, giving rise, consequently, to what will be projections, and the shape of which, and their relation to each other, giving rise, as it may be, to what is called ornament; or leaving only indeterminate projections and hollows, which are known by the name of rough,—still, however treated, the surface of a body must be enclosed by lines, and those enclosing lines have, in the aggregate, the term "outline" given to them. The truth, then, of what has been stated, and profusely and practically illustrated, in the chapters under the heading "The Ornamental Draughtsman"—that every object, however complicated it may appear to be as regards its form, shape, or configuration, is, must be, made up of lines—must be accepted by those who for the first time take up the practical work of ornamental designing. The same chapters also explain how there are, and can be, only two classes of lines—the straight and the curved. Examples of these, together with certain limited combinations of them, will also be there met with. The reader of the present chapter proposing to carry out its instructions and examples is presumed to be master of all those presented in the chapter referred to—"The Ornamental Draughtsman."

Work of the Ornamental Designer.—Meaning of the Term "Ornament."

It is, then, with ornamental outlines the ornamental draughtsman has to do; or rather, we should say, his work is to give to constructed bodies which are in themselves plain an ornamental appearance, which appearance or look is derived from the combination of the two classes of lines we have named, the straight and the curved. Every one knows what is meant by a plain body or surface, this being bounded by straight lines, and the surface itself left in what is called its natural condition. In construction purely as such, this plain body may serve its purpose admirably—that is, it is possessed of utility—but while this is true, appealing only to the sense of propriety, fulfilling thus the conditions of correctness, it makes no appeal to what may be called the higher faculties. No one disputes the fact that it has no pretension to beauty, no matter what the standard may be by which beauty is defined—no standard applies to it. But it will at once be seen that without in any way interfering with, or lessening in any degree, the value of its constructive utility, we may by altering its enclosing lines, and by treating its surface by cutting it up into lines and hollow spaces, impart qualities to it wholly different from those which it before possessed. When we so treat a plain body we are said to "ornament" it, and ornament means simply a thing adorned—from the Latin *ornare*, to adorn. We have thus attained to or reached a point at which, while we do not interfere with the usefulness of a constructed body, we give an added value to it, by imparting to it a quality which pleases the higher faculties of what we have shown to be now known universally as taste. We have still construction, but we have got it graced or adorned; so that we have a new subject, "adorned construction,"or, to revert to the derivation of "adorned" from another name, we may call it "ornamented construction." And we may here note that to distinguish the term "building," which primarily concerns itself with pure constructions of utility, from "architecture," which obviously subserves some purpose other than that of usefulness, it has been by some proposed to define architecture itself as "ornamented construction." And as material is used in construction, the art so defined would embrace the wide range of material at the command of the handicraftsman.

Ornamented Construction.—Simple Illustration of the Term, based on Moulding Design in Surface Decoration.

In applying, then, the broad principles now but briefly indicated, it does not enter into the scheme of the present series of papers to give detailed statements as to this or that theory of the beautiful, nor to give what some call the "canons" or rules of art, which others do not admit to be such; we shall simply accept such outlines or forms as are considered by authorities based upon sound observation of nature in her varied and ever-varying forms; from which, as we have seen, all form must be primarily derived. And it will well illustrate the principle upon which the practice explained in succeeding chapters under the present title, and those in the leading paper of the series—namely, "Form and Colour in Industrial Decoration"—is based, while it will enforce some of these points we have been attempting to explain, if we give here a simple illustration showing at a glance what ornamented construction means, and how it is attained in "Mouldings."

Thus the beam (as *a a*, fig. 1), stretching across an opening, sufficiently fulfils its duty in supporting the superincumbent mass if it be plain throughout—all that is required absolutely for utility being that it is strong enough to bear the weight, and sound enough to keep bearing it for as long a time as possible—the longer the better, of course.

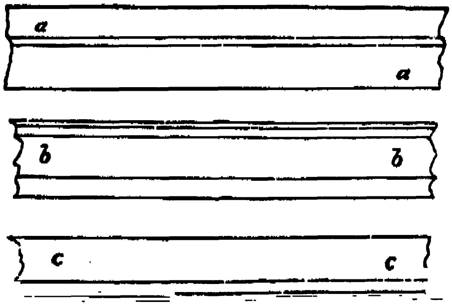

Fig. 1.

THE ALKALI MAKER AND HIS TECHNICAL WORK.

INDUSTRIAL IMPORTANCE OF HIS PRODUCTS—THE MAKING OF SULPHURIC ACID, SODA ASH, CAUSTIC SODA, SODA CRYSTALS, USED IN A WIDE VARIETY OF PROCESSES.

CHAPTER II.

Concentration of Chamber Acid in the Making of Sulphuric Acid.

SULPHURIC acid is strengthened by evaporation either in shallow leaden pans, or in glass or platinum retorts. The first method is largely used where acid of about 1·7 sp. gr. is required for the soda ash process, and is represented in fig. 6. A coke fire is kept burning on the hearth (*a*), and the heat passes over the dilute acid contained in the shallow leaden pan *b*, the outer sides of which are strengthened by iron plates. The concentration is carried on till the acid has risen in specific gravity from about 1·6 to 1·7, beyond which point the evaporation cannot be carried without injury to the lead.

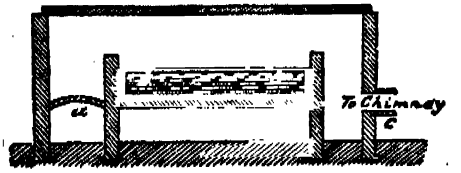

Fig. 6.

The use of platinum retorts for concentrating the acid has nearly ceased, and the strongest acid is now made by concentration in large glass retorts of the shape shown in the diagram fig. 7. The neck *b* rests loosely in the large flask *a*, and serves to condense the acid vapours given off during the boiling of the acid. The retorts are supported on a sand bath and heated by the flames from a coal fire, and are generally arranged in long rows. Each retort contains about twenty gallons of acid, and in spite of the high temperature employed, accidents through fracture of the glass seldom occur.

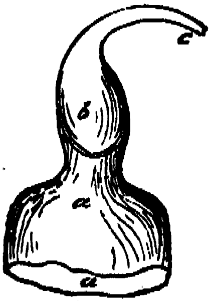

Fig. 7.

Preparation of Soda Ash—Chronology of the Manufacture.

Before describing the various stages of the Le Blanc process, for the manufacture of soda ash from common salt, it will be of interest to give an abstract of Mr. Gossage's "Chronology of the Soda Trade," to show the rapid growth of the manufacture since Le Blanc's time, and the effect of his process on the price of soda.

DATE.	RAW MATERIALS AND PRICES.	QUANTITY MANUFACTURED.	PRICES PER TON.
1790	Barilla and Keep.	Not known.	Not known.
1792	Le Blanc's process invented and used in France.	"	"
1814	Soda crystals made from bleachers' residue, and by Mr. Losh from brine.	"	Soda crystals, £60.
1823-4	Mr. Muspratt's works commenced. Prices per ton: Salt, 15*s*.; Sulphur, £8; Lime, 15*s*.; Coal, 8*s*.	100 tons per week of crystals and soda ash.	Crystals, £18, Soda ash, £24.
1861	Fifty Works in Great Britain using Le Blanc's process. Prices per ton in Lancashire: Salt, 8*s*.; Sulphur from pyrites, £5; Limestone, 6*s*. 8*d*.; Coal, 6*s*.	5,000 tons per week.	Crystals, £4 10*s*. Soda ash, £8.
1883*	Sixty-six Works in Great Britain using Le Blanc's process. Prices per ton in Lancashire: Salt, 8*s*.; Pyrites (50 per cent. Sulphur), 25*s*.; Limestone, 3*s*.; Coal, 7*s*.	5,400 tons per week.	Soda crystals, £3. Soda ash, £4 17*s*. 6*d*

The Manufacture of Soda Ash—Le Blanc's Process.

The manufacture of soda ash by Le Blanc's process is conducted in the following stages:—

I. Manufacture of salt cake (sulphate of soda) by the action of sulphuric acid on common salt.

II. Manufacture of "black ash," by roasting in furnaces a mixture of salt cake, limestone, and coal.

III. Lixiviation of the black ash to extract the soluble compounds (caustic soda and carbonate of soda).

IV. Evaporation of the black ash liquor to obtain soda ash.

In some works the processes stop here, in others the procedure is modified so as to obtain—

V. Soda crystals, by evaporating the black ash liquor to the crystallizing point.

VI. Caustic soda, by removing the carbonate and evaporating the caustic liquor.

VII. Bicarbonate of soda, by carbonating the soda crystals.

Chemical Changes involved in the Making of Soda Ash, by Le Blanc's Process.

The chemical changes which occur in the first two stages are the most important, and are very simple. By the action of the sulphuric acid on the common salt in the first stage, sodium sulphate (called by the workmen "salt cake") is obtained, and hydrochloric acid (muriatic acid, "spirits of salt") is evolved, as represented by the following equation:—

Sodium chloride or common salt ($2NaCl$) + Sulphuric acid (H_2SO_4) = Sodium sulphate (Na_2SO_4) + Hydrochloric acid ($2HCl$).

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* The annexed figures are in addition to those given by Mr. Gossage as above. The author of this paper has been at some pains to get the information—for which, it is needless to state, Mr. Gossage is not responsible.

The acid is condensed in stone towers, and is used for the manufacture of bleaching powder, bleaching liquor, etc., and will be afterwards described among the by-products of the alkali manufacture.

In the next stage of the process two chief reactions occur: the coal reduces the sodium sulphate to sodium sulphide; and the limestone, reacting on this sulphide, produces sulphide of lime and carbonate of soda. These two reactions are represented by the following equations:—

(*a*) Sodium sulphate (Na_2SO_4) + Carbon or coal (4C) = Sodium sulphide (Na_2S) + Carbonic oxide (4CO).

(*b*) Sodium sulphide (Na_2S) + Calcium carbonate or limestone ($CaCO_3$) = Sodium carbonate (Na_2CO_3) + Calcium sulphide or vat waste (CaS).

Such being the theory on which the process is based, we must now proceed to describe how each stage is practically carried out.

The Manufacture of Salt Cake.

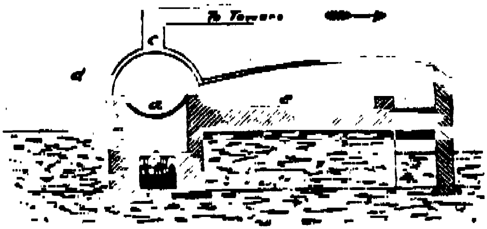


Fig. 8.

The necessary plant for the production of salt cake is represented in fig. 8. *a* represents the "pan" in which the decomposition takes place; it is heated by the fire *b*, and the hydrochloric acid evolved passes up the flue *c* to condensing towers packed with coke kept moist with water, by which the acid is absorbed. About 16 cwt. of salt is used in each operation, and this quantity requires 1800 lb. of sulphuric acid of 1·45 specific gravity, which is allowed to flow on the salt from the leaden cistern *d*. At first the action is extremely violent, and hydrochloric acid is abundantly evolved; but the action soon moderates, and is continued for about an hour, and aided by occasional stirring and by the heat of the fire below. The mass is then nearly solid, and is thrown by means of a sort of iron spade through the narrow opening which connects the pan with the adjoining furnace *e*, called the "roaster." When the charge has been removed from the pan to the roaster, a fresh quantity of salt and acid is added to the pan, and the charge in the roaster is spread over the bed of the furnace, which is heated by the fire *f*, which either plays directly on the salt cake, or on a fireclay arch, which becomes red-hot and so heats the charge; these two kinds are called respectively open and close roasters. The object of the roasting is to complete the decomposition as far as possible, and it is wonderfully efficacious for this purpose, less than 1½ per cent. of salt usually remaining in good salt cake. The hydrochloric acid escaping from the roaster also passes by the flue *c* to the towers, and is there condensed. The hot charge is raked out of the roaster into iron barrows, and is then thrown in a heap to cool, and is ready for the next process.

The Composition of Salt Cake.

The composition of commercial salt cake ought to be about the following:—

Sodium sulphate	95·5
Sodium bisulphate	1·5
Sodium chloride	1·5
Impurities	1·5
	100·0

Manufacture of Black Ash.

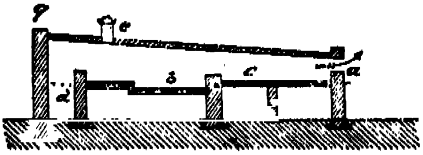


Fig. 9.

The salt cake prepared by the previous process is mixed with limestone and small coal (slack), in about the proportions of twenty parts each of the two first to fifteen of the last. This mixture is then strongly heated in a reverberatory furnace, *b* (fig. 9), until fused, and the red-hot molten mass is raked out into iron barrows and allowed to cool. When shaken out, the mass has the form of the iron barrow, and is then known as a "ball." This is the central process in the manufacture of soda ash, and on the proper mixing and fusing of the charge the success of the operation largely depends. The charge is admitted by a hopper —not shown in the diagram—which terminates the pipe or tube *e*, and remains for some time near the fire, while the previous charge is being treated in the hottest part of the furnace at *b*. Here the charge is spread uniformly over the furnace bed, and constantly raked backwards and forwards by a workman by means of a long iron rod flattened out at the end to a sort of blade, and called a slice. In about twenty minutes the chemical changes begin, carbonic oxide is evolved, and bursting through the pasty mass becomes kindled and burns with a blue flame. At this stage the workman constantly uses the slice and rake, so as to secure uniformity in the mass, which eventually fuses, and is soon after semi-fluid, and is ready to be raked out as already described.

The waste heat of the black ash furnace is often employed to boil down the soda liquor in the pan *c* as shown in the figure (fig. 9).

THE YOUNG ARCHITECT OR ENGINEER.

His Studies—Office Duties—and Practical Work in the Preparation of Working Drawings, of Specifications, and Contracts for Work.

CHAPTER III.

The Ground-Floor Plan of a Building

may be considered the most important of the contract drawings. It represents the floor level with, or only slightly raised above, the street or ground. The arrangement of this plan generally influences that of all the others, both above and below. It might appropriately be termed the entrance-floor plan, as the principal means of access to the building from the outside are shown on it, and they must necessarily control the positions of the corridors, staircases, hoists, and every means of internal communication. Only very few general rules can be suggested for the guidance of the young architect, who can scarcely devote too much thought to the arrangements of this plan. The position of the entrances and staircases in town buildings must be influenced by that of the main street frontage; and as these sites are generally both costly and limited in area, compactness must be combined with a due regard for convenience. When the frontage is a narrow one, the entrance should be placed at one end of the building instead of in the centre, as larger and better proportioned rooms can be planned. Special entrances must frequently be provided for various portions of the building, also for lurries, vans, and goods. If the site has frontages to two streets, it is advisable to place the main entrance in one and the goods entrance in the other. The former should never give direct access to the interior of the building,—an intervening vestibule or lobby should be shown on the plan. When the greater portion of the frontage is taken up by shop windows or other large openings which are not arched over, the architect must show on his ground plan a system of iron supports and girders, or beams, instead of or in addition to masonry or brick piers, to carry the upper stories of the building. The staircases should be placed within easy reach of the main entrance. In public buildings they are important architectural features, and should be planned on a large scale, but in buildings intended for utilitarian purposes appearance and design must give way to convenience. In town buildings the staircases must generally be lighted by means of skylights placed over well-holes, which should be made as wide as space will allow, or by means of borrowed lights. It rarely happens that portion of a valuable frontage can be occupied by a staircase. Occasionally, light can be obtained from an internal area or yard. The general arrangement and grouping of the rooms on this plan will depend, of course, on the purpose for which the building is required. All the principal rooms should open directly on to a corridor, hall, or staircase. Only in special cases should one room be entered through another. All the main walls should, as far as possible, be carried up from the basement to the roof. The young architect should studiously avoid erecting a wall on a girder or beam carried over a room, and should only adopt "false construction," as it is called, after every other means of providing for his clients' requirements have been tried without success. Both girders and beams or supports must be clearly shown on the plan, the former with a dotted line. The supports must, of course, be shown on the basement, sub-basement, and foundation plans.

The ground plan is generally the first of the contract drawings which the architect prepares; and it is, of course, absolutely necessary for him, whilst preparing it, to keep the plans of the other floors, the elevations, and especially the roof plan, prominently before his mind. If young and inexperienced, he may work out an excellent ground plan, only to find that the upper-floor plans will not "work in," or that no reasonable combination of hips, valleys, and ridges will enable him to "roof" his building. Care must be taken in the preparation not only of the ground plan, but also of those of all the other floors, that all walls, piers, shafts, flues, chases, hoists, staircases, and every other "vertical feature," constructional or ornamental, extending through several floors, is shown on the plan of each. Every symmetrically arranged portion of a plan should be drawn from centre lines. Many of the suggestions made above on the planning of the basement and ground-floor plans apply equally to the preparation of the plans of all the upper floors.

The Mezzanine Floor

is rarely required in buildings erected in this country. On the Continent it is a low story placed between the ground and first floors, for various utilitarian purposes, and is always treated, both internally and externally, as a subordinate portion of the building.

The First-Floor Plan

is in most buildings almost as important a drawing as that of the ground floor, and is frequently worked out at the same time, so that the main walls, staircases, etc., can be planned to meet the requirements of both floors. When the plans of the upper and less important stories are prepared, the general arrangements must necessarily be influenced by those of the ground and first floors. Some buildings, as for instance many churches and schools, require only a ground plan, as there are no upper floors; and others (banks and insurance offices) have a first floor of comparatively little importance, as the building is erected to provide certain accommodation which must necessarily be on the ground level; and when it has been planned, the main walls and staircases are carried up, and entirely influence the arrangements on the first floor. It may generally be assumed that the largest and loftiest rooms, in the majority of town buildings, are placed on the first floor. Thus in warehouses it contains the counting house and private offices, in town residences the principal entertaining rooms, and in many public buildings all the largest apartments. The general arrangement must necessarily be based on the position of the main staircase, from which all the rooms must be approached as directly as possible. When they are required for a variety of purposes, those most frequented should be placed nearest the staircase, whilst rooms, staircases and corridors intended mainly for the use of those connected with or living in the building should be so planned that they can easily be shut off from the portion of the building intended for public use. Concert, reading, and other exceptionally large rooms, must be much loftier than the others on the same floor, and must be continued through the story above, in order to be made the necessary height. Portion of the second floor plan will consequently frequently become a gallery plan. The outside walls on the plan of the first floor are generally drawn half a brick, or, if built of stone, three or six inches, thinner than those on the ground-floor plan. Additional space may sometimes be obtained by corbelling out a bay or oriel window, but in town buildings all projections are generally limited by building by-laws enforced by the local authorities. In houses erected in the country, intended for domestic purposes, the rooms shown on the first-floor plan are generally bedrooms. When they are being planned, the young architect must never forget the special use for which the rooms are intended, or he may find when too late that the windows, door and chimney-breast are so placed that no room is left for the bed. It is usual to indicate its position on the drawing by a dotted parallelogram and diagonals.

The Second-Floor Plans

are not, of course, always required, as many buildings are limited to two floors above the ground level. When they have to be prepared, all the features of the floor below—for instance, staircases, shafts, flues, hoists, areas, etc.—must be carefully obtained from the first-floor plan, and laid down on the drawing; provision must also be made for carrying the roof. The architect is consequently considerably fettered in the planning of these floors. In some buildings they are almost exact repetitions of the first-floor plans. Thus, in workhouses and hospitals all the upper floors are generally formed into wards, and the same general arrangement is adopted on each story, with modifications in the thickness of walls, number of flues, etc. In dwelling-houses the whole of the upper floors are generally occupied by bedrooms, and the arrangement of the plans is entirely subsidiary to that of the main floors. In many warehouses the upper stories are of the utmost importance, on account of the good light that is obtained, and every effort is made in the general arrangements of the plans to utilise them to the greatest extent; the window openings must be made as large as possible, and the whole of the space in front reserved for the display of goods. In many buidings the upper floors are devoted to uses as varied as those mentioned in the remarks on the planning of the basement or cellar plan. The top floor of hotels and club-houses generally contains the kitchen, which must of course be planned so as to be in direct communication, by means of hoists, with the dining-rooms, streets, and the coal-cellar. Billiard-rooms are frequently placed on the top floor and lighted from the roof, as well as picture galleries, studios, etc. When special wants have to be provided for, the young architect must make himself thoroughly familiar with the object for which the rooms are required, so as to be able both to prepare his plans and to specify the materials and construction most suitable for them.

Plan of Roof Timbers.

This plan is essentially different from those that have been described above. When the architect is preparing the plans of the ground, first, and upper floors, he is entirely guided by the requirements of his clients, and the special object for which the proposed building is to be erected, his sole aim being to devise the best arrangement of rooms, staircases, entrances and corridors that the site will admit of; but when engaged on the plan of the roof timbers, the architect's attention is entirely devoted to construction. This plan, like that of the foundations, will frequently require a number of small marginal sections to make it complete. If the roof is shown on the elevations, the general arrangement of the ridges, gables, hips and valleys must be taken from them, but if it is entirely concealed by parapets—which is generally the case with buildings designed in the Classic or Perpendicular Gothic styles—they can be arranged without reference to the elevations. After the ridge-pieces, hips and valleys have been drawn, add the purlins, principals, and pole or wall-plates; they may be, as already stated, indicated by centre lines, but it is advisable to draw them to scale. The spars or rafters are drawn next, and then the details, including hip and valley boarding, gutters, cesspools, angle ties, and trimming for the chimney-shafts, skylights and dormers. If a lantern-light, etc., rises above the line of slating, the construction must be shown. The inclination or pitch of the roof depends on the style of the elevations. The dimensions of all the main timbers and ironwork must be figured in the drawings.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER II.

WE concluded the preceding chapter by referring to the circumstances connected with the working of an ordinary pump, which led up to the discovery, by Toricella in the sixteenth century, of the law of atmospheric pressure. We do not say that this law would not have been discovered had the contrivance of the pump not existed; but we have to deal with the fact that it was the existence of a pump which would not work under certain circumstances in the same satisfactory way that other pumps had worked under other circumstances, that did actually lead to the discovery of the law. And we find that this peculiarity in the history of practical mechanism or engineering has been exemplified in a wide variety of instances. For generation after generation practical men had been devising contrivances to do useful work, and by patient labour had succeeded in introducing improvement after improvement, not merely in their general design, but in their actual construction, by improved methods of workshop practice; and yet all had been done by what was literally "rule-of-thumb" practice. And it was only when not merely the amount but the comparatively efficient condition of mechanical work, both in structures and machines, had arrived at a certain important stage, that learned men began to apply scientific reasoning and research and mathematical investigation to all this wide variety of mechanical contrivances and structures, and discovered the formulæ and arranged the rules and calculations which we the successors of the mechanics of the olden times use daily in finding the exact forms and dimensions which give us the maximum of mechanical effect and strength with the minimum of material. But while this is true in the main, and while it is a point which practical men, so called, are apt to glorify themselves and "their craft" in, it would be as unjust as it would be wrong for the mechanical student to decide in favour of the long and still contested point, that "practice is before theory." On the contrary, this great fact must ever be borne in mind, that

The Combination of Theory and Practice is essential to all Mechanical Progress, to the Adaptation of Natural Phenomena, and to all the Processes and Operations of Industrial or Mechanical Work.

For the intelligent reader, exercising his gift of a fairly balanced mind, will not fail to perceive that the course we have above cited, which is but one of many of a like kind, while it may, by the purely practical man, be applied as a proof of greater value of practice over theory, inasmuch as the scientific man or theorist could have done nothing without the work of the practical man, constitutes just as powerful a proof that theory is before practice, inasmuch as, had the theorist or man of science not discovered the law of atmospheric pressure, none of the wide range of practical work which resulted from its knowledge would have been effected. Indeed, if the position as between theory and practice be forced forward, it would appear that theory is the more important. For in these later days we have evidence abundant enough of positively new fields for the work of the practical man having been created simply by applying laws and discoveries which the purely scientific man has found out. But little surely need be placed before the student to prove that the true position of the theorist and the practical man is, that each is essential to the other before the work in view can be actually done: the head can no more say to the hand 'I can do without thee' than the hand can say the like to the head. As in the body social, so in that mechanical, all are dependent each man upon his neighbour; and the fields which each has to cultivate are surely wide enough, and the work to be done in each important enough, to give occupation without any jarring of interests. From all that has been said—and we could say a vast deal more, so prolific and inexhaustible is the field of observation and research open to us—it will be seen by the student that

A Knowledge of Natural Laws and of their Phenomena is essential to the Mechanic.—The Great Inheritance of Accumulated Facts bestowed upon us by our Predecessors.—Its Value to the Student and Practician.

All machines, however complicated in their construction and in the movements or motions which characterise them, when analysed or stripped of what may be called their outer integuments, will be found in every instance to be dependent upon some one natural law or another. In other words, the parts used by the mechanic, however much they may give evidence, as they do give evidence, of his intellectual powers in creating *combinations* to do certain work, could not possibly do that work if those natural laws did not exist, or existing as they do, if they were not obeyed; or so controlled that they are not allowed to act, as they can be controlled either wilfully or by ignorance, the most ingenious-looking arrangement of mechanical parts would be worth nothing, and this is simply the reason why so many machines which promise fair are failures. It would appear, therefore, to the student that no one would be so foolish as to fight against nature, to use a familiar expression. But the history of man in the mechanical world abounds with too many and too painful instances of what man has done and suffered in this very same and hopeless cause. If a correct knowledge of natural laws was possessed by practical men, we should find but few examples of what are called practical failures.

And the reason why we have made such enormous progress in mechanical work is simply this—that we have entered, so to say, into the inheritance accumulated by men in former days, in following closely in the lines which natural laws indicated. It is impossible for us now to overestimate the value of this inheritance.

Popular or General Overlooking of the Difficulties the Early Workers had to do in bequeathing to us the Valuable Inheritance of Accumulated Facts.

It is, however, too true that so far from being likely to err in this overvaluing of it, as a rule we seldom think about it, and when we do, we fail to comprehend all that it conveys, or to think of what work our predecessors had to do, and the enormous difficulties they had to encounter at every step of their progress. We talk and write glibly enough of the wonderful work we do in this nineteenth century of ours; but if "judgment was to be laid to the line and justice to the plummet," in this matter the decision would be that our predecessors did in reality work infinitely more difficult than we do. They had everything to find out and do: they had not only to find out all about materials, whether they were adapted or not to their purposes, but they had by patient labour, and this under the most disappointing and disheartening of trials, to find out and make the tools by which the materials were worked into shape and form, and fitted together to serve the object in view. And no less, but infinitely more disheartening, the efforts must have been to find out *how* these purposes could be served. Every step, and that the least equally with the most important, had to be taken with infinite labour, and each attended, as all must have been at the first, with most disheartening mistakes. We have all this ready to our hand, and it is ever an easier thing for man to improve than to discover or invent, easier to do work with the accumulated experience of a host of predecessors, than when we have no experience of our own. It is comparatively easy to reach a certain point in a country when the road is laid out for us; the hardest labour was what our predecessors had to do, not only in the making of it, but in finding out whether its direction would take them to the point to which they desired to go. This last point, indeed, which represents the root or base of a matter, is but too apt to be forgotten by those who trudge easily along the road, certain that it will take them to their destination. All labour such as this pointed out has been done for us, and as it is of necessity the most difficult, we have at least less occasion to talk and write so glibly of what we do. We are the last, as indeed we should be the last, to underrate the vast importance of the mechanical work we actually do in this wonder-working age of ours. All that we here contend for is that the student should think well over how much we are indebted, in the doing of it, to those who found out not merely the lines upon which we work, but the appropriate materials and the methods of working those which seem essential to it.

Valuable Lessons to be learned by the Student from the Foregoing Circumstances in the History of Mechanical Work.

And this thinking out we do not recommend to the student of the laws of mechanics simply as an interesting object of study. It has thus an intense interest, but it possesses something more. Its educational influence is of the highest order, and the student cannot possibly rise from its study without having learned lessons of the highest value to him in his daily practice; nor is it at all unlikely, if he be himself gifted with some at least of the attributes of genius, that in learning something of the discoveries of his predecessors he may be led to make some discovery of his own. But if from the study we here recommend him he learns no other lesson than the habit of patient inquiry and laborious painstaking exertion, he will in truth be more than repaid for such work as the study has involved. And he will assuredly rise from it with the profound conviction of the priceless value of the inheritance bequeathed to the mechanics of the present day by their ancestors, and he at least will not be disposed to take up and use, as a mere matter of course, aids and helps to work, without thinking of what had to be done by those who gave to them a practical existence. We shall find, as we proceed to glance at the natural laws on which all mechanism is based, numerous evidences in illustrations taken from practice of the difficulties which surrounded the discovery even of points in construction and design of mechanism of which the great majority of us talk as if but trifles, to which no thought whatever is necessary to be given. But, leaving this wider illustration to future paragraphs, it will serve all the purposes we have here in view if we allude in the briefest way to circular motion or movement. This is one of the things of which we avail ourselves in a variety of ways, as a mere matter of course. But those to whom thought on the subject is new will doubtless be somewhat surprised to learn that there is every probability that it took man ages—a positive certainty that it must have taken at least many generations of experience in life—to find it out; and when, to slightly vary the words of one of our ablest modern machinists, he did find it out, it proved to be one of the grandest mechanical discoveries he ever made, because it fitted in so conveniently with the nature of things as they exist in the world, or was the most preferable and most convenient for man to deal with and control, to receive, store up and to convey force in motion. Of the points essential to be considered, in this and in other departments of mechanism, full information will be found in the various paragraphs of succeeding chapters.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

25. The Condition of Belts as affecting their Economic Working.—The Different Strains to which the Sides of the Belts are exposed in Working.

(*See* Notes Nos. 1, 2, 6, 16, 17, 18 and 19.)

IN the various papers which form the text of the TECHNICAL JOURNAL, the reader will have more than one example of the importance to the mechanic of considering how the *condition* of the materials or substances he uses in his work of construction affects the strength of those and of what is technically called their working "life." This is but another way of reminding the young reader that there is the best way, as there is also the worst way, in which a material can be used—tending either to increase or lessen its powers to resist destructive force—and between those two extremes there are, or may be, a series of changes of condition, each affecting the value of the material from a constructive or practical point of view. This element of "condition" is one too often overlooked by young mechanics, and by old ones also for the matter of that, and if so, to their great loss and disappointment. It is a point which should be thought over, and evidence on it, as given by experienced men, should be gathered as extensively as possible by the beginner in the art of mechanical construction.

This element of condition is one which affects in the closest way the use of belting in transmitting power. We are now considering "leather" belting, as that is the material most generally used. To one not considering the subject from every point of view (for remarks on this as closely concerning the success of a mechanic, see the opening or introductory chapters of the paper in the text entitled "The General Machinist"), on examining a leather belt it would appear to be a matter of very little moment which side or surface formed the inner one, that is, the surface running in contact with the pulleys. Little difference between the one surface and the other could be traced by a mere cursory inspection. But there is in reality a great difference in the condition of the two surfaces. Made from the skin of an animal, there are two surfaces, one of which was originally the outer, or that which, being covered with the fur or coat of the animal, is called technically the "hair side"; the other that which, of course, was nearest or next to the body of the animal, and is therefore technically designated the "flesh side" of the skin. Now, the skin as a whole is made up of a series of "fibres," which may be likened to the threads or yarns forming the warp or longitudinally running threads of a piece of woven cloth (see the paper in the text entitled "The Factory Worker"). Taking a strip of skin, or say tanned hide, of equal thickness and breadth throughout, and stretching it when laid or held perfectly flat by pulling at either end, the longitudinal strain thrown upon the fibres in this condition will be distributed, so to say, throughout the fibres of the hide, so that those of the top side or surface, or near it, will be pulled no more forcibly than those of the lower side or surface. This strain is called technically a tensile strain, tending to pull or separate the fibres asunder in the direction of their length, and is the strain to which the flat or free part of a driving belt between or after it has left the pulleys is subjected.

But the parts of a driving belt which are laid on, or pass over, the rounded surfaces or arcs of the pulley peripheries are under quite another condition of strain, or rather conditions of strains. If the reader has a thickish strip, or what will be better, as showing the effects more clearly, a length of a rubber rod circular in section—and will bend it round so as to form as it were a circular loop or hoop—he will, on examining its upper or outer half, perceive that the fibres are considerably stretched; while those on the inner or concave side are compressed or squeezed together. And if, commencing by forming a small bend or loop, he gradually keeps enlarging its curve, the more he enlarges this the less stretched will be the fibres of the upper or convex part, and the less squeezed together or compressed will those of the lower or concave part be; till at last, by gradual opening up of the curved loop the rubber rod is allowed to become flat, when the fibres of both sides will be equally free from strain. Or if the rod be pulled apart at both ends, the strain, as in the case of the strip of tanned hide, will be equal on both sides; and this strain will be a tensile one, or the rod will be under what is called tension. When the rod is bent round a curved or circular surface, the fibres of the convex or outer part, farthest from the surface, are alone under tension or a tensile strain. The fibres of the concave or inner side, nearest or in contact with a curved surface, are in a state of compression, or are subjected to what is called a compressile strain. And the smaller the diameter of the curved surface—as that of a pulley—the greater will be the proportional difference between the conditions of the fibres of the convex and concave sides of the rod or band—that is, the more will the fibres of the convex side be stretched, and the more completely will those of the concave side be compressed. And the force tending to destroy or rupture the fibres is the tensile one, or that which tends to draw out or separate them, the compressile or squeezing strain being comparatively or practically harmless. The young reader will find given in due course, in the series of papers entitled "The Carpenter," explanations and illustrations of the different "strains" to which materials are subjected by the action of forces or pressures.

26. Practical Points connected with the Working of Belts in relation to their Surfaces.

The losses and disappointments met with by many mechanics who have either overlooked in their practice in constructing and fitting up of pulleys for driving gear of all kinds, or who have been ignorant of the "conditions" under which fibrous materials are placed in the circumstances above named, have been severe and numerous. And those "conditions" affect all kinds of driving media, whether they be in the form of belts or straps or ropes or bands of leather, or hide, or india-rubber, or cotton, or of hemp, manilla, steel or iron wire. The working "life," alike of a driving "belt" of leather, or of a "rope" of iron or steel wire, dependent upon several conditions which will be hereafter named in the series of "Technical Notes," is perhaps more influenced by the way in which the proportions of the pulleys in regard to diameter or "size" are designed, than upon any other condition. Other circumstances being equal, the larger the diameter of the pulley the more likely is the "life" of the driving media, be it belt or rope, to be extended. The evils of the converse, or opposite of this, have been, as we have said, experienced by not a few, to their great loss and disappointment.

But there is this difference between a driving rope or band, and a driving belt or strap of leather. In the rope or band, of whatever material it be made, if well made, all the fibres are of equal strength. So also in a belt or strap of cotton, or of vulcanised india-rubber, or of gutta-percha. But the belt or strap of leather, being made of the skin or hide of the animal—generally cattle—is under different conditions, the fibres of the two surfaces of the skin or tanned hide being of different structure, so to say, and strength. The "flesh side" of the skin, and of course, ultimately, of the tanned hide, of which the driving belt is made, gives the strongest fibres; and this, the stronger side, extends through the skin or hide to about one-third of its full thickness. The "hair side"—frequently, if not, indeed, more generally termed the "grain side"—is more dense and compact in its fibres than those of the flesh side, and their tendency is to crack or open up, while that of the fibres of the flesh side is to give way or extend under a tensile or stretching-out force or strain. The compact character of the "grain" or hair side gives also greater smoothness to the surface, and a fuller or wider bearing of it on the surface of pulley is therefore secured. As showing the difference in point of strength between the flesh side of a tanned hide or leather belt, and the grain or hair side, the following experiment may be cited. A belt was split down the middle of its thickness, thus giving two belts or straps, one of which was the grain or hair side, and broke under a direct strain of 468½ lb.; the other was the flesh side of the leather, which took a much greater weight (740½ lb.) to break it.

Noting these facts—which have by observation and experiment been proved to be so—one would conclude that there would be no diversity of opinion as to which side of a belt should run in contact with the pulley surface, and remembering them always in connection with the conditions of strain to which driving belts are subjected, as explained in Note 2, p. 39. Yet, notwithstanding this, great diversity of opinion and of consequent recommendation for practice does exist amongst mechanics who have had much to do with belt driving gear. Thus the young or inexperienced reader, after being made acquainted with them, would be somewhat puzzled to meet with this dogmatic, confident assertion—which has, however, been made—"*Every one* knows that the strength of belt leather is in the hair side."

If this were so, the obvious inference would be that a driving leather belt should be so placed on the pulleys that the flesh side should be next or run upon the surfaces of the pulleys, thus throwing the grain side or hair side to the outer or free surface. Now, we have seen that the grain or hair side is that which, being most compact, is apt to crack or open up under strain, and that the greatest tensile or opening-up or stretching-out strain is on the upper side of a belt bent over a curved surface. This placing of the grain side outside is the very worst and weakest position in which it can be worked. The grain or hair side should, on the contrary, be next the pulley, as in all good practice it is, and as recommended—notwithstanding the diversity of opinion we have alluded to—by the great majority of—indeed, nearly all—good mechanics. When the grain side is thus placed, the flesh side, being now outside, is precisely in that position in which the condition or character of its fibres enables them to resist the tensile strain thrown on them by passing round the curve of the pulley. The grain or hair side gives also better adhesion or "friction" to the belt, the surface being compact and smooth, so that the greatest part of it lies on or grips the pulley, which would not be the case with the rougher flesh side.

This explains how also the grain or hair side next to the pulley surface gives greater driving power to the belt so placed. This is estimated at one-third more than the power obtained by a belt placed the converse way. The results of a series of experiments made by a house having a high reputation in belt-driving power may be thus stated, showing the comparative working value or percentages of strength or of driving power of leathern belts driven in the two ways we have noted, and of belts of other materials. Thus a leathern belt driven with grain or hair side to pulley gave 31 per cent., or say one-third more driving power; driven with flesh side to pulley 23 per cent., or less than a quarter. A vulcanised india-rubber belt gave 21 per cent., or but a little lower than the last named, a gutta-percha 14 per cent., and a canvas band 11 per cent. Stated another way, "a leathern belt grain side to pulley will drive 34 per cent. more than flesh side to pulley, 48 per cent. more than india-rubber, 121 per cent. more than gutta-percha, and 180 per cent. more than canvas."

27. The New Standard Wire and Metal Gauges.—The "Birmingham" and "Lancashire" Wire Gauges.—Various Technical and Constructive Points connected with the Subject of Interest to the Technical Student in Construction.

In Note No. 7, p. 85, we gave tables of the "New Legal or Standard," the "Birmingham," and the "Lancashire" wire gauges. In examining the "Birmingham," the oldest and most widely used of all the gauges, and which is the base of the New or Standard gauge, it is difficult to see upon what principle it has been arranged. On its face it bears evidence that its various dimensions were more matters of chance than of a guiding principle. Many attempts have been made to ascertain the manner in which the dimensions of this gauge arose, and how they were recorded. What appears to us to be the most likely way in which these dimensions were established is that suggested by Mr. Latimer Clark. It is, to say the least of it, a common-sense way of accounting for what, it must be confessed, it is not now an easy matter, if indeed it be a possible thing, to account for in such a way that it will be accepted by all as the precise method by which the gauge as it has so long stood was arrived at. Considering the period at which the Birmingham Wire Gauge—designated in all contracts, specifications, etc., by the letters "B. W. G."—was introduced, now very many years ago, it is not likely, as Mr. Clark remarks, that they called in or themselves adopted the aid which mathematical or physical science could have given them. The almost certainty, simply looking at the facts and circumstances of their work, and the period in our mechanical history at which they lived, is that they just took the sizes of wires as then made, and from them constructed a wire gauge, in which they would be included, and with which other and new sizes would be compared. At one time, and of necessity from lack of power and appropriate machinery, all wire was "drawn," to use the technical phrase, by hand power or manual labour. The largest size then made was three-tenths of an inch in diameter. This might be said to mark the outside or extreme limit to which hand power could go in the operation of wire drawing.

It may well and safely be assumed that this, the maximum diameter which hand power could give, would have been exceeded had that power been greater, for there was no reason to stop at this size — many business reasons to exceed it, as it has since, with greater power at command, been exceeded. And it may also be safely assumed that the precise dimensions which this the largest wire then drawn possessed, were much more a matter of chance than of a predetermined desire to have it of this diameter. Taking this the largest size of wire then made, the wire drawers would make at one operation or "draw" the next size most conveniently drawn; from this again they would "draw" at one operation the next size; and so on till the smallest wire made would have a character so small, or the wire would be so "fine," that it would be represented by some thousandths of an inch. The operation of reduction with the hand power only at command would always be the easiest, and would, in fact, only be limited by the purity of the metals used, and by the high percentage of extensibility, or, to use the very graphic word coined by Mr. Clark, "drawability."

In process of time the "wires" thus sent out to the "trade" would become so extensively used, and in something like a regular way dependent upon their diameter or size, that a means of referring to them in definite and generally understood terms would be demanded. To meet this essential in drawing up contracts or specifications, or in sending "orders" for supplies of wire, which would probably be the first and most urgent cause, the manufacturers would see the necessity of establishing a standard or system by which all the wires could be "gauged," to use the popular phrase, and referred to in a definite way, recognisable and accepted at once by the makers and the users. The easiest way would be to give to each size or diameter of wire a certain fixed and invariably used "number." And the series of numbers sufficiently great to take in all the sizes then made would naturally begin with 1. And this would as naturally be given to the largest size of wire made—three-tenths of an inch in diameter, as we have seen—which would therefore be called "No. 1" of the gauge, the descending series in size being of course indicated by ascending numbers. The next smallest size drawn at one operation would thus be "No. 2," and so on.

That this was the course adopted is in a measure proved by the evidence of the "B. W. G." as established. For we find that, a new power being given to the wire drawers, they could draw wires much thicker than three-tenths of an inch in diameter—the "No. 1" of the "B. W. G." With each unit of increase, they had to find a new number for it in the gauge; but as they had already established "No. 1," and as descending sizes had ascending figures allotted to them, they had no alternative but to go backwards, so to say—that is, in the "zero" direction. Thus the size above three-tenths of an inch—No. 1—was called "No. 0," and the next largest size would obviously be "No. 00," or "No. 02," and so on. We have thus indirect proof, so strong that it may be taken as direct, that when the "B. W. G." was established, the largest size which could be practically, that is, in an economical or business paying sense, drawn, was three-tenths of an inch, or what was called, and is still called, "No. 1."

The various gradations of sizes drawn in the earlier times we have referred to would have their relations to each other decided in like manner—that is, by the circumstances under which the work was done. For we may safely assume that, as in the standard sizes adopted, so here, there would be no abstruse mathematical or delicately adjusted physical aids called in to define the precise relation which an ascending number, as "No. 5," would have to the one preceding, or "No. 4," or to the next ascending number—"No. 6." This relation would be decided by circumstances, or, to use Mr. Clark's words, the "relation of the succeeding sizes would be determined between [by] two considerations." For economical or "paying" reasons, the wire drawer would aim at drawing down the wire to the smaller size, or the smallest size possible at one operation or "draw." This would obviously be cheaper than to get the size by two or more "draws." But this work would clearly be limited by the "power" he had at command, as well as by the character of the metal, or its cohesive strength, he employed. Practice would in process of time enable the wire drawer to balance, so to say, those opposing forces; and thus a "mean," which would be the most profitable or best paying, would naturally be established in the manufacture, which would give a series of definite sizes. If the diameters of these were transferred to, or their dimensions cut out in, narrow strips or slots in the edge of a plate, and if to each of those a number were given, arranged in the way we have already stated, the maker and the user alike would be able to determine the diameter or the "size per gauge" of any given wire, or the thickness of any piece of sheet iron or metal, by simply passing in the given wire or piece of metal into the slot corresponding to it in size in the plate, which would in itself be the measuring plate or gauge.

Such may be taken as a fairly common-sense explanation of the way in which the "B. W. G." was established; and if it be correct, it might be presumed that in investigating the series of numbers or sizes there would be a "constant relation between the breaking strength of each wire, and the resistance opposed to the draw-plate in drawing it down from its original diameter." Such a relation is found to exist. There are several points connected with wire gauges which are not only interesting, but having a wider application than to this subject alone, are well worthy of the consideration of the young student in mechanics. To one or two of these we shall devote our next note.

28. Bessemer Steel Castings.—Method of Working to ensure Soundness and Solidity.

In Note No. 8 we opened up this important subject, and concluded by a reference to the lack of homogeneity or uniformity in the metal—which, unfortunately, in too many cases, is its characteristic. To one conversant with the process (see "The Steel Maker" in the text), and to those who have seen the Bessemer metal "turned" into a large ladle ready to be run into the ingot moulds, one can easily understand how the opinion to which in the former note we alluded is prevalent among so many, that it is a ladleful of a material which, in its apparently unsettled, seething, boiling condition, is by no means fitted for giving sound, solid, and homogeneous castings. It would seem to be the very nature of the process to yield this condition, to which the term "frothy" might be applied as giving some idea of what it is. To compare small things with great, the mass is like a beaten-up egg which has been whipped up to make a light porous syllabub, or one of those pretty tempting dishes to which, in our ignorance of cookery, we cannot now give a name. The beaten-up egg presents a very different appearance from the homogeneous and, if we may so call it, the solid or close condition of the egg before it was beaten up. Now, this seething, boiling mass of Bessemer steel, as it comes from the converter, is not in a fixed or a permanent condition—which, as some maintain, cannot be altered, but must convey or retain its characteristics when the metal has been cooled and settled into its solid condition. To return to our illustration, it is like the whipped-up egg: the process of converting has done for the metal what the beating did for the egg, and a light, porous, blown-up mass is the result. It is well known, however, to those who have much to do with the mixing and agitating of various substances, that a mass which has been so agitated that it has become frothy, porous, and honeycombed, may, by having thrown into it or mixed with it some other substance in a different condition, be made, so to say, to collapse or fall down or subside, the frothy condition disappearing and a close or what may be called a solid state resulting. The bulk of the mass is the same, but its physical condition is different. The substance thrown into it, which has acted as the quieting or solidifying agent, may or may not be a deteriorating substance, and if it be, the object in view of the operator will be to throw in as much of it as will complete the quieting or settling, and no more. Now, in Bessemer steel we have a case precisely analogous to this now illustrated. The very "lively" state in which the steel is on being passed into the ladle is found to be so amenable to the action of certain substances, that it may be soothed or quieted down until it is got into that condition in which it will give sound and solid castings. Those substances thus so valuable are ferro-manganese, silicide of manganese, or silicide of iron; and they are just as available and valuable for Bessemer steel as they are known to be in steel made by any process other than that of the Bessemer converter. But in the works of Henry Bessemer and Co., of these soothing or quieting agents, ferro-manganese is the only one used. And, as stated by Mr. W. D. Allen, of this Company, who read a paper before the "Iron and Steel Institute" last year, and which forms the basis of the present "note," a ladleful of Bessemer steel *judiciously* alloyed with ferro-manganese "will run dead and lie perfectly quiet, sinking into the mould like ordinary cast iron, and a large dead head will always be necessary to feed the casting. In this way are cast cranks, side-cranks, cross-heads, cylinders, rollers, spur-wheels, and various other similar pieces of machinery, which, when finished bright over their whole surface, show neither blow-holes nor blemish of any kind." We have above italicised the word "judiciously," for it is to be here noted by the reader not intimately acquainted with all the details of the steel-making process that the quieting, soothing substances or alloys above alluded to, are in themselves, in relation to the Bessemer steel with which they are mixed, impurities. If they be in excess, they give a harshness and hardness to the steel, taking from it in like proportion "that beautifully soft, ductile nature" which is the characteristic of good Bessemer steel. We have just used the word "mixed." To return to the familiar illustration we gave at an early part of this "note," it is known that, by throwing in a certain solid substance in the shape of a powder, a frothy, puffed-up liquid will be quieted. But the quieting process is only partial, and is not completed until the whole mass is thoroughly stirred, mingling the "quietener," so to term it, and the liquid together. Now, apart from any effect in this direction of the process or "blow" (see "The Steel Maker" in the text) itself, the act of turning the metal from the converter into the ladle created such an agitation or violent action that the materials were most imperfectly mixed. To express the condition in popular language, in place of lying closely together they are separated by bubbles of air, just as the beaten-up liquid or semi-liquid of the egg already noticed became frothy, and, as the familiar expression has it, full of air; and just as gentle, continuous stirring is substituted for the violent agitation of the whipping or beating of the egg liquid, so does the frothy condition subside and the mass become homogeneous. The same result would ensue if the frothy mass were allowed to remain perfectly still for some time, the air gradually escaping from the mass; or a like result would follow if it were very gently poured from one vessel to another, and this more than once, according to circumstances. To get rid of the "occluded" gases (for this term see the "Cyclopædic Technical Dictionary"), a method has been introduced of treating the Bessemer steel while in the ladle, and this simply by stirring it with a mechanically worked "agitator." To some of our readers it will appear an odd thing to stir a huge mass of molten steel at an excessively high temperature as one stirs his cup of tea; and certainly, on looking for the first time at a huge ladleful of the glowing mass of melted metal, it does seem a daring idea to take in hand to stir it. What kind of a spoon, the young reader may ask, can be used which will not be itself melted? and what stirrer can be found which or who can stand the fierce heat raging above and around the ladle? These and all other points will be explained in a succeeding "note," which will embrace a brief description of this most important improvement in Bessemer steel making. Meanwhile we conclude this by stating, in relation to the question of Bessemer steel castings, that Sir Henry Bessemer himself, in the discussion which followed upon the reading of Mr. Allen's paper, already alluded to, stated that he had "seen such (sound) castings made by the hundred without a single (gas or air) bubble, and without the "agitator" it would have been impossible, even with the hammer, to hide the bubbles."

29. Indigo Printing on Calico.

Natural indigo has long held—and notwithstanding many substitutes, yet continues to hold—an important position amongst dye wares. Indigo dyeing is comparatively a simple matter, and also the production of a variously-coloured pattern containing light and dark shades of indigo blue, by the discharge process; but indigo dyeing and discharging are expensive processes. Indigo printing is more difficult of accomplishment, and according to the old methods is unsatisfactory, only *light* shades of blue being obtainable. The subject of dyeing and discharging indigo blues will be found treated in the papers on "The Calico Printer." Recently much attention has been devoted to the producing of indigo blues directly upon calico by printing. Perhaps the hitherto disappointing results obtained with artificial indigo and other substitutes for the natural product, have induced fresh efforts to be made in this direction. The following process, more or less modified according to varying circumstances, now adopted by many large firms on the Continent and in this country, is that carried on at the works of Messrs. Schlieper and Baum, of Elberfeld. By its means blues of any depth of shade, and in a great variety of patterns—either singly, on white or on Turkey red cloth, or combined with several other colours—may be obtained, and at a considerably less cost than that of the dip or indigo dye and discharge process.

For indigo printing a special shop is built, and arrangement is made for the prevention of draughts in the room; moreover, it ought to be kept at a uniform warm temperature. Each printing machine is provided with a special arrangement for drying the cloth both before and after printing, and also a special steaming apparatus. The principle of the process is the *reduction* of the natural indigo to white indigo by the action of glucose in presence of an excess of caustic alkali and steam, and the absorption of the solution of white indigo by the fibres of the cloth, and the subsequent *oxidation* of the indigo, which remains firmly fastened in the fibres of the cloth.

1. *The Preparation of the Cloth for Printing upon.*—The cloth, whether white bleached calico or Turkey red dyed cloth, is first run through a solution of glucose (grape sugar) at 12° Tw., in a preparing machine, and squeezed between rollers and dried. Immediately before printing, it is necessary to dry the glucose-prepared cloth a second time, glucose being hygroscopic.

2. *Preparation of the "Colour" for Printing.*—A standard colour is first made by grinding 25 kilos. of good indigo, containing 70 per cent. of indigotin, in a granite mill, with 50 to 70 parts of water, for two days. As much water is then added as will make the mixture weigh 125 kilos.; this is removed into the iron pan of a balance, the pan being suspended in an empty trough, the other pan outside the trough containing the weights; 50 litres caustic soda solution at 70° Tw. are then added; then 58·53 kilos. solid caustic soda 90% are added, and the mixture stirred with an iron spatula and kept at a temperature of 40° C. by means of running water into the trough. This is called the standard colour, and from it any desired shade of printing colour is prepared. It is preserved in iron boxes with hydraulic lids, to prevent access of air, the carbonic acid of which would form crystals of carbonate of soda in the colour by uniting with the caustic soda.

To prepare the colour for printing, 3 kilos. British gum and 1·5 kilo. Indian corn starch are mixed with 3·75 kilos. cold water, in a pan standing in a cold water bath; 19 kilos. caustic soda at 70° Tw. are then gradually added and stirred with a wooden spatula, 27 kilos. of the standard colour, as prepared above, are then added, and the mixture is well but slowly stirred. Less or more standard colour than this quantity may be added if a lighter or darker shade of blue is required, but in any case the standard colour and caustic soda together must weigh 46 kilos.; the difference between this weight and the weight of the standard colour must therefore be made up with caustic soda. The standard and soda having now been added, the mixture is heated to 70° C., with constant stirring, and then cooled. The colour is now ready for printing; it may be preserved uninjured for several months in hydraulic pots.

3. *Printing the Colour.*—The colour, colour-box, and "doctor" are made tepid warm; the colour being very thick is constantly stirred during printing, and the glucose-prepared and dried cloth is printed in the ordinary way; immediately on leaving the printing roller it passes along a warm iron plate, then passes into a long box through which is passing a current of air at a temperature of 70° C., by which it is dried to such an extent that to the touch it is but very slightly moist.

4. *Steaming the Printed Cloth.*—The printed cloth now passes out of the air-drying apparatus, and is allowed to cool, and at once passes into a specially constructed steaming chest, containing pure steam free from air, and in 20 seconds passes out. The action which takes place in this steaming operation is the key to the whole process. The soda attracts moisture, and the solution of soda and glucose acting upon the indigo reduces it to white indigo, which dissolves in the caustic soda and penetrates the fibres of the cloth. On coming out of the steaming chest the pattern is therefore olive-brown-coloured, and quickly oxidises to blue by exposure to the air. The printed pieces are taken and run open through a washing machine, and most of the soda and glucose thereby washed out; they are then squeezed between rollers and exposed to the air for a short time. Next they are washed in an ordinary washing-machine, in the rope form, and dried on drums, which completes the oxidation of the indigo; lastly, they are passed through very dilute caustic soda at boil, washed and dried, and the cloth is ready for finishing like ordinary prints.

The cost of the colour, with the present cost of materials, as above described, and containing 27 kilos. "standard" colour in 54 kilos. printing colour, amounts to 3*s.* 1½*d.* per piece of 66 yards; dip or dyed blue of the same shade costing 3*s.* 7½*d.*; the cost of both varying equally, of course, with the price of indigo. The above is a description of single indigo blue pattern, but different effects may be produced by employing a *resist* containing precipitated sulphur and padding; also combinations with alizarine are produced. But space does not permit of our entering into these variations in the process.

30. Data Useful in Mechanical Calculations, and in making out Estimates for Work.

(1) *Weight in pounds and decimal parts of pounds of a cubic foot and a cubic inch of Different Metals.*

	cub. ft.	cub. in.		cub. ft.	cub. in.
Cast iron	450·5	0·260	Copper	549·2	0·317
Rolled malleable iron bar	486·8	0·281	Lead	709·5	0·410
Steel	489·6	0·283	Tin	455·6	
Brass	489·0	0·283	Zinc	429	0·248

(2) *Weight in pounds of a square foot of Various Metals one-sixteenth of an inch in thickness.*

Cast iron, 2·34 lb.; malleable or wrought iron, 2·52; steel, 2·55; brass, 2·73; copper, 2·89; lead, 3·70 lb. When three-sixteenths in thickness the weights in the order above given will be: 7·03, 7·57, 7·65, 8·20, 8·67, 22·25 lb. The intermediate thickness, or one-eighth of an inch (*i.e.* $\frac{2}{16}$), will be found by doubling the weight per foot of the one-sixteenth thickness.

(3) *Weight in pounds of a square foot of Sheet Iron or Plate in various thicknesses.*

$\frac{1}{16}$th inch thick	= 2·54 lb.	$\frac{5}{8}$ths inch thick	= 25·20 lb.
$\frac{1}{8}$th „ „	= 5·05 „	$\frac{3}{4}$ths „ „	= 30·31 „
$\frac{1}{4}$th „ „	= 10·10 „	$\frac{7}{8}$ths „ „	= 33 „
$\frac{3}{8}$ths „ „	= 15 „	1 „ „	= 40·5 „
$\frac{1}{2}$ „ „	= 20·20 „		

(4) *Weight in pounds per lineal foot of Wrought Iron Rods or Round Bars of various diameters.*

2 in. diameter	= 10·47 lb.	1 in. diameter	= 2·61 lb.
1$\frac{7}{8}$ths „ „	= 9·2 „	$\frac{7}{8}$ths „ „	= 2·00 „
1$\frac{3}{4}$ths „ „	= 8·01 „	$\frac{3}{4}$ths „ „	= 1·47 „
1$\frac{5}{8}$ths „ „	= 6·91 „	$\frac{5}{8}$ths „ „	= 1·02 „
1$\frac{1}{2}$ „ „	= 5·89 „	$\frac{1}{2}$ „ „	= ·654 „
1$\frac{3}{8}$ths „ „	= 4·94 „	$\frac{3}{8}$ths „ „	= ·368 „
1$\frac{1}{4}$th „ „	= 4·09 „	$\frac{1}{4}$th „ „	= ·163 „
1$\frac{1}{8}$th „ „	= 3·31 „	$\frac{1}{8}$th „ „	= ·040 „

31. Portland Cement Concrete.

In Note No. 3 we gave a brief general description of Roman and Portland cements, their constituents and relative strength; and we now proceed to put together a few notes as to their practical use. Practically these will refer, as a rule, to Portland cement concrete. It need scarcely be said that, to get good results in construction, the best—certainly, at the least, good—Portland cement must be employed. It is perhaps less necessary, unfortunately, to say that this involves the fact that there are bad as well as good qualities in the market. Adulteration is not more likely to stop at cement making than at any other branch of manufacture; and where it can be easily carried out, as in the case of this cement, it may well be understood that it is frequently so. There are, indeed, in the market Portland cements which are so only in name, not in fact, and which are not worth having at any price where good, sound, honest work is looked for. It is not, however, always easy to detect the presence of adulterating material. But, fortunately for the purchaser who does only honest work, the adulterating materials generally used lack the feature of ponderosity which the true cement possesses. This affords a means of knowing the quality of any cement sold as true and good—namely, by its weight. Portland cement, to be good, should weigh not less than 102 lb. to the bushel measure. But in our practice we preferred a heavier weight—say of 110 to 112 lb. For the best work the maximum weight should be used. Where the amount of work to be done is extensive, the tensile strength of the cement should always be tested. The tensile strength should not be less than 300 lb. to the square inch. A range from this to 350 lb. may be considered safe. The cements made by our best manufacturers show, however, a far higher tensile strength than this—450 lb., and up to a fraction within 500 lb., being often, and indeed as a rule, obtained. Where the architect or engineer has large weights of Portland cement to deal with, it will be well to have it tested in regard to its chemical combinations or constituents, as well as to its tensile strength. A few remarks on these two tests will be useful here.

In respect to its chemical character, the percentage of lime is a point of the greatest importance, any excess of this being very prejudicial to the strength of the cement. This may be ascertained by what may be called a chemical test, and, as is generally done, by a physical one. In a pure or well made cement the lime is not present in the form of a carbonate of lime, analysis showing the absolute absence of this, although it is present in the "slip" or "slurry," or first semi-liquid mixture of the materials before they are calcined, and this to an extent of more than one-half. But cement is, as we have said, but too frequently adulterated; and amongst adulterating materials, ground limestone or chalk is employed. The presence of this can be detected by the use of muriatic or hydrochloric acid. A weight of 5 grammes of the cement may be taken to be tested, and the acid to be poured on it is diluted with water in the proportion of four parts of water to one of pure acid—50 grammes of the dilute acid being used for 5 grammes of cement; or in like proportion if our weights be used. The dilute acid being poured on the cement, and the whole well stirred with a glass, wooden, or gutta-percha rod, if chalk or limestone be present effervescence or ebullition takes place, and the amount of this may be taken as roughly determining that of the adulterating material used. In pure cement no effervescence will take place, as lime is present only in what may be called the combined form, with a small percentage from 1⅘ths to 2⅓rd of sulphate of lime.

When there is an excess of lime which has not been properly combined in the calcining or burning, there is a tendency in the cement to crack or disintegrate when exposed to atmospheric influences, under the ordinary conditions of building, or when used for hydraulic work—the cracking being caused by the expansion of the lime in excess. The presence of this is ascertained by the physcal test we have alluded to. This is carried out in a very simple way by taking a sample of the cement and making, with the aid of water, a small mass of concrete. This should be formed into small cubical masses, and those—in number as many as may be deemed desirable—placed on pieces of slate, and allowed to "set." On being "set," the masses, along with the slates on which they rest, should be immersed in water, and allowed to remain quiescent therein for a period of not fewer than three days. And it is obvious that the longer the masses are allowed to remain in the water, the better will be the test. If after two or three days the masses show no cracks or evidences of disintegration or breaking up, it may be decided that there is no undue excess of uncombined lime. In forming the test masses or lumps, the quantity of water for mixing up, or making the concrete with the cement, should be as small as possible, consistent with the free working of it into the masses required. The more shapely, so to say, these are made, and the more regular their surfaces, the better, as the facets or corners will so much the better display any cracks or tendency in the concrete to crack or disintegrate.

We may conclude this note by stating that the acid test for lime or chalk adulteration may be applied when it is supposed that ground slag—from its fineness—has been used as an adulterating material. When a dilute muriatic acid is mixed with the cement, the solution takes a yellowish hue should the cement be free from the adulterating material, and does not become tinted; but if this be present, the solution becomes tinted or milky, and a strong smell of sulphuretted hydrogen gas is felt, this arising from the presence of sulphur in the slag. It is right, however, to state that in Germany the manufacture of a cement from pure iron slag is carried on, and the quality in its tensile strength is stated to be beyond the usual standard. We require, however, to have more definite results on this point. In our next note we shall chiefly describe the mode adopted for testing the tensile strength of Portland cement, preliminary to the explanation of other and practical points connected with the use of this important constructive material, the manufacture of which is now carried on to a great extent, and with the application of very complete machinery.

32. Data and Rules for Building Calculations and Estimates.

(1) *Sizes and Average Weights of, and Surfaces covered by, Slates used in Building.*

Names of the different classes of Slates.	Dimensions.	Average weight per 1200.	Estimated Surfaces, in "Squares" of 100ft. superficial, per ton.
Queens . . .	32, 34. 36″ by 16, 17, 18″	....	....
Princesses . . .	30 by 15″	115 cwt.	16¾ sq.
Ditto	28 " 14″	97 "	14¼ "
Ditto	26 " 13″	82 "	2½ "
Duchesses . . .	24 " 12″	65 "	11 "
Marchionesses .	22 " 11″	54 "	9 "
Countesses . . .	20 " 10″	43 "	7¾ "
Viscountesses . .	18 " 9″	35 "	6 "
Ladies	16 " 8″	25 "	4¼ "
Small Ladies . .	14 " 7″	19 "	3½ "
Doubles	12 " 6″	13 "	2½ "
Imperials, for roofing, various lengths . . .	5 to 7″ wide 8 " 10″ "		

(2) *The Length of Timbers, Joists, or Beams required to make a Cubic Foot of various sized Scantlings—that is, with a given Breadth or Thickness with various Depths or Widths.*

No. 1. The breadth or thickness being 2 inches.—With a depth or width of 2 in.—that is, a section of 2 in. square—the length required to make a cubic foot of the timber will be 36 ft. Keeping throughout to the one breadth or thickness of 2 in., the following will be the lengths required to make a cubic foot; of depths or breadths increasing by half an inch, commencing with a depth or breadth of 2½ in., up to and including that of 12 in. Thus 2″ by 2½″ will require a length of 28 ft. 9 in. to make a cubic foot; 2″ by 3″ = 24′ 0″; 2″ × 3½″ = 20′ 7″; 2″ × 4″ = 18′ 0″; 2″ × 4½″ = 16′; 2″ × 5″ = 14′ 5″; 2″ × 6″ = 13′ 1″; 2″ × 6½″ = 11′ 1″; 2″ × 7″ = 10′ 3″; 2″ × 7½″ = 9′ 7″; 2″ × 8″ = 9′; 2″ × 8½ = 8′ 6″; 2″ × 9″ = 8′; 2′ × 9½″ = 7′ 7″; 2″ × 10″ = 7′ 3″; 2″ × 10½″ = 6′ 10″; 2″ × 11″ = 6′ 6″; 2″ × 11½″ = 6′ 4″; and finally, a joist or piece of timber 2″ × 12″ requires a length of 6 ft. to make a cubic foot.

33. To find the Breaking Weights in pounds of Beams of various kinds of Timber.

Take the square of the depth of the beam in inches, multiply this by the breadth of beam, also in inches, and multiply the result by the "constant" for the particular kind of timber employed; finally divide the quotient thus obtained by the square of the length of the beam, also in inches. For "constants" see next Note (No. 34).

34. Constants for "Breaking Weights" used in calculating the Strength of Timber Beams to support given Weights, or to sustain given Pressures.

(1) Oak (English), 1,775; (2) Oak (Canadian), 1,766; (3) Elm, 1,350; (4) Ash, 2,026; (5) Beech, 1,693; (6) Larch, 1,149; (7) Riga fir 1,325; (8) Red pine, 1,342; (9) Pitch pine, 1,632.

35. Thermometer Scales—Fahrenheit, Centigrade.

Of late years there has been a marked tendency to introduce into our scientific literature, and to use in scientific investigations, the Continental (French) weights, measures, and scales. The French system, as is well known, is on the "decimal" method of calculation. In all calculations and disquisitions connected with heat, the Fahrenheit thermometric scale was at one time universally used in this country. But of late the "Centigrade" has been largely employed by our scientific men. By long usage we have got so accustomed to refer all indications of temperature or heat to the Fahrenheit scale, in which the leading or popular point is the "boiling point of 212°," that when statements of temperature according to the Centigrade thermometric scale are given, one has a natural desire to know what the given temperature is as judged by the Fahrenheit scale. The converse, though necessarily not so popular, is useful. The following gives, first, various temperatures in the "Fahrenheit," and, second, in the "Centigrade" scale: — 212° F. (boiling point), 100° C.; 200° F., 93·3° C.; 180° F., 82·2° C.; 160° F., 71·1 C.; 140° F., 60° C.; 120° F., 48·8° C.; 110° F., 43·3° C.; 100° F., 37·7° C.; 90° F., 32·2° C.; 80° F., 26·6° C.; 70° F., 21·1° C.; 60° F., 15·5° C.; 50° F., 10·0° C.; 40° F., 4·4° C.; 32° F. (freezing point) 0·0°, or "zero," C. To convert the temperature given under one scale into the corresponding temperature in the other scale is frequently required or desired. To convert the degrees named according to the "Centigrade" into degrees of the "Fahrenheit" scale:—When above zero or freezing point—deg. in Fah. + deg. in Centi. × $\frac{5}{9}$, or thus: $\frac{32\ \text{F.} + \text{C.}^\circ \times 9}{5}$ = Fah. deg. required. When the Centigrade degrees named are below zero or freezing point, deduct the degrees in Centi. scale from 32° Fah. scale. When it is desired to convert degrees named according to the Fahrenheit scale into corresponding degrees in the Centigrade, if above freezing point, the given degrees in Fah. + 32 × 5, and divided by 9, will give the degrees Centi. required. If below freezing point, the given degrees in Fah. — 32 × 5 and divided by 9—is the formula.

36. Drawing Paper—Dimensions of the Usual Sizes or Varieties.

(1) Wove Antique, 52 in. by 27 in.; (2) Double Elephant, 40 in. by 26 in.; (3) Atlas, 33 in. by 26 in.; (4) Columbia, 34 in. by 23 in.; (5) Elephant, 27 in. by 23 in.; (6) Imperial, 32 in. by 21 in.; (7) Super Royal, 27 in. by 19 in.; (8) Royal, 24 in. by 19 in.; (9) Medium, 22 in. by 17 in.; (10) Demy, 20 in. by 15 in.

37. Brands, Grades, or Marks of Drawing Pencils.

(1) Very dark, black, or soft, B B. (2) Black or soft, a degree less than (1), B. (3) Moderately soft and dark, H B. (4) A pencil for softness or darkness of its line between H B and the next grade (5) is marked or branded as F, and is used for the general work of rough sketching, writing, etc. (5) H, Hard, for drawing lines finer than (4). (6) H H, or double H, still harder than (5), for finer lines. (7) H H H, or "treble H," the hardest pencil in general use, employed in the finest architectural and engineering drawings (see "The Building and Machine Draughtsman").

38. The Relative Influence of Illuminating Agents, as Candles, Gas, etc., in Vitiating Fresh or Pure Air

is shown by the following. The agents are presumed to be consumed in giving a light equal to twelve sperm candles. Thus, while tallow or ordinary candles consume of oxygen 12·06 cubic feet, the same consumption or lighting power will produce of carbonic acid gas 2·01 cubic feet. Taking the agents as follows, these are their relative vitiating influences on the atmosphere. Wax candles, consuming 8·41 of oxygen, produce 5·90 of carbonic acid gas; sperm candles, 7·57 O., 5·27 C.; stearine or paraffin candles; 8·82 O., 6·25 C.; common coal gas, 5·45 O., 3·21 C., Cannel coal gas, 3·30 O., 2·01 C.; sperm oil, 4·75 O., 3·33 C.; paraffin oil, 6·81 O., 4·50 C.

39. "The Domestic Side of Sanitary Science

deals with home comforts, and the unit in this case is the house, then the village and the town. Houses must be planned, constructed, and regulated to afford means of health and morality to the occupants. Villages and towns must be so arranged, built, sewered, paved, and scavenged as to preserve the purity of the soil below, and the air above, for the benefit of the inhabitants. To secure such ends there must be sewers, drains, pavements, scavenging, and a water supply. . . . The cleanest-looking places are not always the safest (in a sanitary sense). A clean-looking country house or village, surrounded by pure air, free from coal and smoke, may have hidden dangers worse than any in a town. Visible (external) dirt is not always the most dangerous, as the rain washes it, the wind blows over it, and the sun dries it. The presence of rats either in town or country (within or immediately about a house) is a certain indication of danger (sanitary), as rats live on garbage. They are usually diseased, and can convey the seeds of disease."—*Address to the Sanitary Institute of Great Britain by Sir Robert Rawlinson.*

(9) In another part of our work a few paragraphs will be found on "Cements," one of the most interesting, as in many respects one of the most extensively useful departments of industrial work. Very good cements are often classed as being the opposite of this, simply because they are improperly applied or used—a result, be it noted, in many classes of work other than that of cementing. Some cements require one mode of application, some another; but all demand one thing—namely, that the surfaces of the bodies to be joined at the joint shall be clean, this referring specially to the absence of all grease, or oily or greasy matter. Getting rid of this, as it is an essentially important so it is a more difficult matter than it may appear at first sight to be; at least, it requires greater care than some are disposed to exercise. We have had to deal with cements so fine that we have found the natural greasiness of the hand to act prejudicially in preventing proper adhesion.

(10) Those who have had much to do with gluing and cementing, if observant, must have noticed that the joined or cemented or glued bodies, although apparently well and carefully done, will "suddenly separate or fall away from each other." It would almost seem as if each kind of cement had its own peculiar lasting power. The writer, who has paid some attention to the subject of cement, has, for example, noticed through an experience of some years, that one particular kind of cement greatly used for joining articles of glass and the like loses its gripping or holding powers somewhere between the ten and twelve months—and this although the cementing was done with the greatest care. The pieces fall suddenly away from each other without any obvious weakening at one part more than at another, the giving way extending or acting over the whole surface at once. This retention for a limited period of the holding power of cements opens up more than one curious scientific point. We know that molecular changes in bodies take place under certain circumstances, and it might be worth inquiry how it is that the change is brought about in the case of some cements. To the annoyance of many, common glue frequently displays this tendency to lose its holding power—not showing a weakening gradually, but quite suddenly giving way. Examination of the faces of the separated joint seems to point to excessive brittleness as the cause of the glue giving way. This brittleness, and with it the tendency in glue to lose its hold, is overcome by mixing with the melted glue a little glycerine. Experience alone will show how much should be used. If the articles are kept in a very dry or warm place, the quantity of glycerine required will be greater than if the situation be a little more humid.

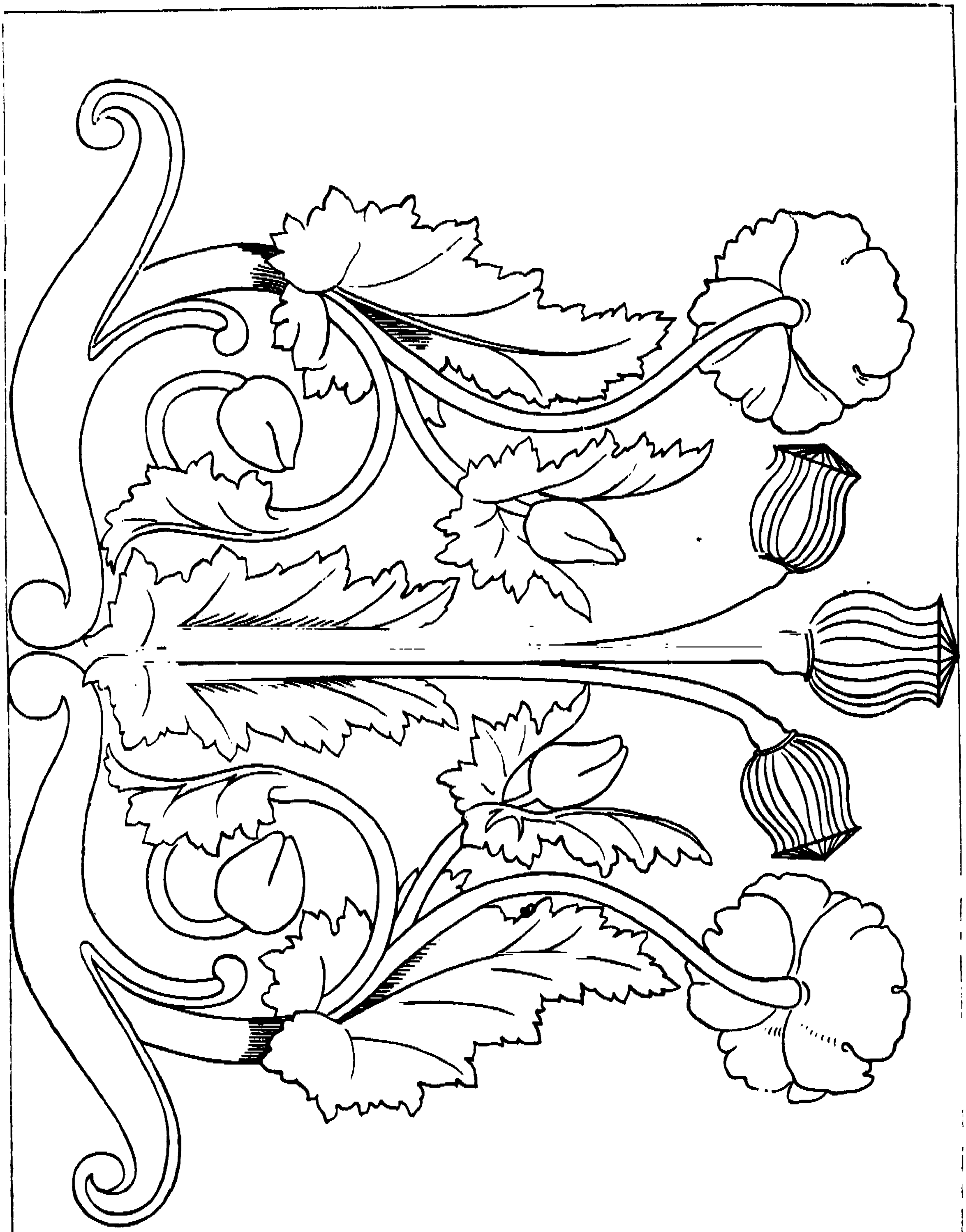
(11) In Note No. 5, on the subject of "steam raising," we saw that the operation of boiling of water resulted in the creation of a force, the steam raised representing so many units of mechanical power capable of doing mechanical work of some kind as obtained from so many units of heat. A "unit of heat" is the heat required to raise one pound weight of water one degree of the thermometric scale in temperature; and a unit of mechanical force—or as it is generally termed power—is the work done in raising a weight of one pound (avoirdupois) through a vertical distance of one foot. Hence the term "foot-pounds" used in estimating the amount of mechanical force or power. Looking upon the operation of "steam raising," which is virtually that of "boiling," as the manifestation or production of a force capable of doing work, the subject for the student is invested with a practical interest, the points of which will well repay his most earnest attention. It is one which, with its side issues, would require much space to do it full justice. In the limited amount of this we have at command, we can only glance at its leading points. In the "raising of steam" we have certain essential elements to deal with: first, the "water," which is the body which under certain conditions yields the gaseous fluid or watery vapour called "steam"; second, the "heat" by which that vapour is created, this heat being in practice produced by the "combustion of fuel," in which process the ordinary atmosphere or "air" plays an essential part. On the combustion of fuel and on air we shall have notes to present to the reader in this section of our work; and we hope to find space for another series, on "water," a substance or body which plays one of the most important parts in the physical phenomena of the globe, and a not less important part in our industrial work. Meanwhile, of the characteristics of water it will be essential to our present purpose to glance in briefest fashion at one of its most important, namely, its "capacity for heat." Of all the bodies with which man has to deal in the varied work of life, water is the one which is capable of absorbing or taking up the greatest amount of heat, there being only one exception to this—the metal known as platinum. This

capability of water to take up the greatest amount—to carry, so to say, the heaviest burden of heat of all the bodies known to man—is of the greatest service to him. And the fact that this affinity for heat, to use a chemical expression, is associated with an element so universally met with all over the globe, and which from its physical properties lends itself with such ease to the varied works of man, is not a mere coincidence, but is to our mind another of the many instances we have of beneficent creative design. If we place a vessel of "cold" water upon a briskly burning coal fire, it gradually changes its condition, and becomes what is called "hot." These terms hot and cold, be it remembered, are purely relative. A body having a certain temperature may be called "cold" compared with another body which has a higher temperature, while conversely it might be as truly said to be "hot" when compared with another body possessing a lower temperature than it. Strictly, there is no such thing as absolute cold or heat. Certainly we cannot positively declare that below the lowest temperature man has been able to produce there is not still a lower; and the converse is equally true. By recent improvements in furnace construction, and in methods of consuming fuel, we have now in daily use temperatures of a height which not many years ago practical men would readily have pronounced to be unattainable; and who would now venture to assert that we shall not be able to reach higher temperatures still? In the simple experiment named above, the cold water placed on the fire *gradually* becomes hotter, as shown by the thermometer—going through the stages of first cold, next lukewarm, then warm, and finally very hot. We here make a distinction between the terms warm and hot, which are usually considered as synonyms; but the term warm is generally applied to bodies in a condition in which the temperature is on the average low, the term hot being applied when the temperature is on the average high. As before said, there is nothing absolute in the conditions. After the water has reached a certain stage of heat, it becomes more or less violently agitated, and from its surface a white vapour passes away, to which the name of "steam" is given. If now the vessel be taken from the fire and exposed to the ordinary air, it will be found in testing it by the thermometer that the water *gradually* grows colder, till it reaches at last the same temperature as that it originally possessed—namely, the normal one of the surrounding air. If, in place of removing the vessel from the fire after it had reached the point of ebullition or boiling, it had been allowed to remain, the water would *gradually* have disappeared till the vessel would be what is called "boiled dry"; or, in more scientific terms, the water would be wholly evaporated, passing into the open air in a vapour. And these three conditions—the cooling, the heating, and the evaporation or drying or boiling up of the water—have all been gradually brought about; that being an important element in the three operations. And although to the young student it might appear to be a desirable thing to have boiling and steam raising done at once—saving time and fuel—a little consideration will suffice to show that the feature of graduality, so to call it, which distinguishes the processes we have named, is really a beautifully designed law. If, for example, the moment water had reached the temperature of the boiling point (see a succeeding note), at which the water changes from the liquid into the gaseous or vapoury form, the change had been instantaneous, the production of steam would have been as dangerous as the firing of gunpowder, and it could not have been used, as it is used, as a motive power; the steam engine and its boiler could not have been the convenient instruments they are in the hands of men. Other manifestations of this beneficent law of the gradual operation of physical effects could here be named. We can only merely allude to the natural processes going on around us every day in equalising the temperature of the globe, and in making it fitted for the habitation of man. The total amount of heat required to bring water to the boiling point is called technically the "quantity of heat." And this is taken up by a succession of portions of heat abstracted from the source of supply of the heat, this succession being a necessity of the gradual way in which water becomes hot. Those portions are technically called "increments," the meaning of which term will be gathered from the Latin verb from which it is derived—*crescere*, to increase, to augment, to add to, and *in*. An "increment" may therefore be considered a particle or molecule of heat—if, indeed, we can conceive of those material terms being applied to a something which we call heat, but which is at once invisible, intangible, and imponderable, and of which what it is, or how produced, we know absolutely nothing; all that we do know being how to avail ourselves of its peculiarities in the doing of our work. But this considering of increments of heat as solid particles may enable one more readily to conceive of them as being taken up, absorbed into, or mingled with the constituent particles or molecules of various bodies which man in varied industrial processes subjects to the influence of heat, to serve certain purposes or bring about certain results. And as each possesses its own peculiar properties, making it different from all other bodies, so each body will have its own peculiar relation to some one particular agent, differing from the relation of some other body having different characteristics or properties. Thus two bodies in relation to the agent water will display two different properties. One body being dense, or with its particles closely packed, so to say, together, will, when exposed to the water, take up or absorb fewer particles or increments of it; while the other body, being less dense or porous, as it is termed, will take many more increments of it. And in both cases, while there is, so to say, a different mechanical affinity for water in the parts of the two bodies, they both resemble each other in this,—that there is no chemical reaction or change set up in their constituents, so that if the water be wholly driven off from each, each will possess precisely the same properties which originally characterised it. And just as different bodies have different relations to the elements of water, so different bodies have different relations to the element of heat. Each body possesses its own capability to take up, absorb, or carry its own burden, so to say, of heat increments; and we repeat that it is a beneficent arrangement in the laws of nature as designed by an all wise Creator, that a body or substance like water, which enters so largely and so universally into the operations of nature on the grand scale, and in the thousand-and-one operations and processes of man in his industrial work in the small yet to him important scale, is precisely the one which possesses the greatest affinity for heat with one exception, and that one the costly, comparatively rare, and seldom used metal known as platinum, which has more than three times greater affinity or capacity for heat than water. Water, therefore, is chosen as the standard by which the capacities for heat of all bodies are measured, the standard having the numerical value of 1000 given to it.

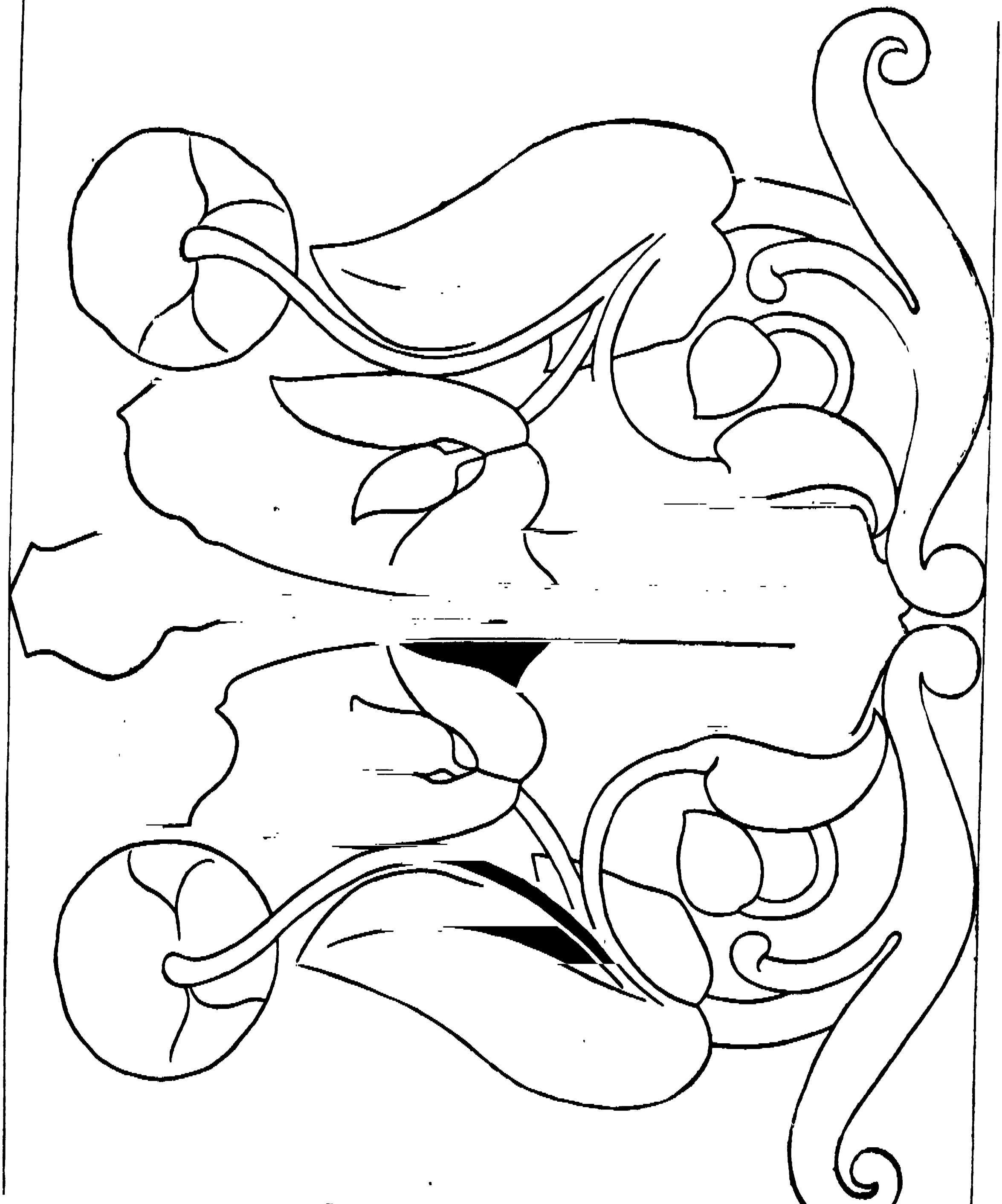
(12) "Varnishes" are so very extensively and largely used in the arts, that a note or two about their peculiarities and characteristics may be useful to a large number of our readers. A "varnish" may be defined to be a clear limpid fluid or liquid substance easily and readily applied as by a brush to surfaces of solid bodies, such as those made of the more valuable woods, and when so applied dries rapidly and sets or hardens, so as to give a shining face or glossy surface to the body or object treated with it. When set and hardened it should reflect and refract the rays of light as a covering of glass would—which substance is to a solid what a varnish is to a fluid. While thus acting with light, the peculiarities of the surface to which the varnish is applied, such as the "grain" or "humour" of wood, are brought out and, so to say, intensified, making them, and also all colours such as pictures, more bright and brilliant than they are without the varnish. A very good idea of a varnish and the effects of its use is gained by brushing or sponging a surface of smoothly wrought wood with clean clear water. So long as this remains a thin film of liquid on the wood seen in a strong light, all the effects of a varnish are produced. The following are the characteristics of varnishes which should be aimed at in making them. Not only because the free working of the varnish is dependent upon this quality, but because its economical use is affected by it, a varnish should possess a high degree of fluidity—that is, it should flow freely from and be readily and uniformly laid on the surface by the brush. The practical importance of this quality is obvious; for unless it can be laid on the surface with the utmost facility—if it be viscous, or as we call it "sticky"—it is not possible to spread it over with that uniformity which alone gives perfect work. Uneven laying on is simply equivalent to giving thicker layers at some points than at others, so that varying media are formed through which the surface beneath is seen, and thus its shades or colours are in some measure altered, and the bringing out or brightening of these, which is one of the great objects of varnishing, is, to a greater or less extent, lost. Fluidity or readiness to flow from the brush and over the surface makes the varnish the more economical in use, as a greater surface will obviously be covered than if the varnish is viscous, or does not readily flow from the brush. The second desirable characteristic in a varnish is its clearness or absolute transparence—its limpidity. For just as the clear limpidity of the water of a rivulet flowing through a rural district, remote from the dust and smoke soot of cities, enables one to see the shiny pebbles and water plants at the bottom not only as clearly but even with their colours more brilliantly developed than when seen through the haze of a summer day's air, so a clear limpid varnish not only does not obscure the tones and shades of the surface it covers, but actually brings out and makes them more pronounced and brilliant. Defile the water of the country brook with some solution which clouds its clearness, or have some ingredient which has the same effect upon the varnish mixed with it, and its value as a varnish is lessened in proportion to the extent to which the debasing ingredient or constituent is present. The third characteristic which a varnish should possess is rapidity in drying. From the very nature of a varnish, if it does not attract dust and particles of dirty or extraneous matter to a surface on which it is laid, certainly before it dries it takes hold of and retains any extraneous matter which falls upon it, and entraps insects which alight upon it, and also is subjected to the influence of certain changes in the atmosphere which will impair the brilliancy which it is so desirable to retain when one has been so fortunate as to make a varnish which gives this. The quicker, then, a varnish dries after it is once laid on, the more valuable it is, and the less care is requisite in protecting the varnished surface from all substances which are likely to fall upon it, or from atmospheric changes which may affect it. The fourth characteristic a varnish should possess is its rapidity of hardening.

When a varnish is dry some suppose it is hardened, but the two properties of dryness and hardness are quite different, and therefore independent of each other. Hardness implies, and must carry with it, the solidifying of the ingredients of the varnish. A varnish may be dry, yet not solid. The value in a varnish of this property is apparent. The fifth characteristic of a varnish is the capability to retain its valuable characteristics. To borrow a term from the race-course or the hunting field, the varnish must have "staying" powers—a term indeed employed by painters in describing this important property. A varnish should keep its "fullness" (another term to denote this characteristic) and show its brilliancy after it is dried and has become solid or hardened, and the longer it does this the more valuable it is. The next characteristic of a varnish is its "glassiness" or glossiness of surface, or, as it is more frequently designated, its brilliancy. This is indeed implied in what we have stated to be the general characteristics of a varnish. Unless a varnish be brilliant it fails to yield one of its most pleasing peculiarities. The seventh characteristic of a varnish is its elasticity—a property which enables it to "give and take" with any changes or expansions and contractions of the material on the surface of which it is placed, and prevents it from cracking and scaling off. This quality generally follows in a varnish when it possesses the other qualities named above. The eighth characteristic of a varnish is its capability to resist atmospheric agencies, the corroding action of bad air, gas-light effluvia, etc., etc. The last and the most important of all of the characteristics of a varnish is its lasting qualities, or the length of time through which it retains all the good qualities we have named. This characteristic of a varnish, this durability, unlike the other qualities we have named, can only be tested by length of time; the other qualities may be tested by a few trials. Generally speaking, if a varnish be first-class in respect of the qualities we have named, it will be a durable one; always, be it noted, however, involving this fact—that it be not exposed to abnormal or unusual conditions, which are markedly unfavourable. This involves care in the keeping of varnished objects, and in not exposing them to influences which are obviously inimical to them. In this, as in other departments of work, the quality of the materials, or the way in which the work is executed, or both of them, may be and are often blamed when the censure is alone incurred by carelessness on the part of those for whom the work is done. There is a mode, unfortunately too frequently met with, of so carelessly treating and dealing with work which has been really conscientiously well done, as not to give what is suggestively called fair play either to materials or workmanship. One word in concluding, at least for the present, a subject possessed of much scientific and practical interest; and that is, on the importance of so choosing or selecting a varnish that it will be suitable to the physical or mechanical characteristics of the surface or material to which it is to be applied. It is obvious that a varnish which will bring out and enhance rather than deteriorate the natural features of one material or object will not be calculated to do the same office for another material of a totally different character. This, no doubt, involves the necessity of thoughtful care on the part of the maker and workman in varnishes; and where this is not given, he can scarcely lay claim to the title of an intelligent and clever operator.

(13) In a series of notes in this department of our Journal we shall explain the special points connected with the "boiling of water," the "raising of steam," one of the most important of the practical operations with which the handicraftsmen of all classes are interested, inasmuch as upon steam depends by far the largest amount of mechanical or motive power produced and used in this country, and which to a greater or less extent is used in nearly every branch of industrial work. In the production of heat by the combustion of fuel, as air, the ordinary atmosphere, is an essential element, we shall have to consider its special characteristics; and as the "combustion of fuel," almost universally in the form of coal, is the agency by which in practice we generate heat, we shall have in the present series of notes to explain the characteristics of "fuel," and the special points of "combustion" by which heat is produced and the raising of steam is effected. (The following paragraph and others yet to follow will take up the subject of Fuel.) Fuel may be defined as a solid substance composed of organic constituents, which under ordinary circumstances remains unchanged by the air, but under the influence of heat of a certain temperature—about 617° Fah. or 326° Cent. for coal, and for wood 593° Fah. or 295° Cent. —combines with the oxygen present in the ordinary air, and which itself must also be heated to the same temperature, "takes fire," to use the common or vulgar phrase, or, to use the technical one, enters into "combustion," and is consumed so far as the organic constituents of the fuel are concerned, leaving a residue known as the "ash," which, being inorganic or mineral, is incombustible, the ash constituting a very small proportion of the bulk of the original fuel. The heat necessary to start combustion or "burning" in a fuel is in the first instance applied through what is called a "kindling" or "lighting" medium, a body in active combustion easily lighted; but when a mass of fuel is once fairly burning, or in active combustion, it produces heat high enough to light fresh fuel thrown upon it, and thus keep up or maintain combustion so long as fresh additions of the fuel are supplied.

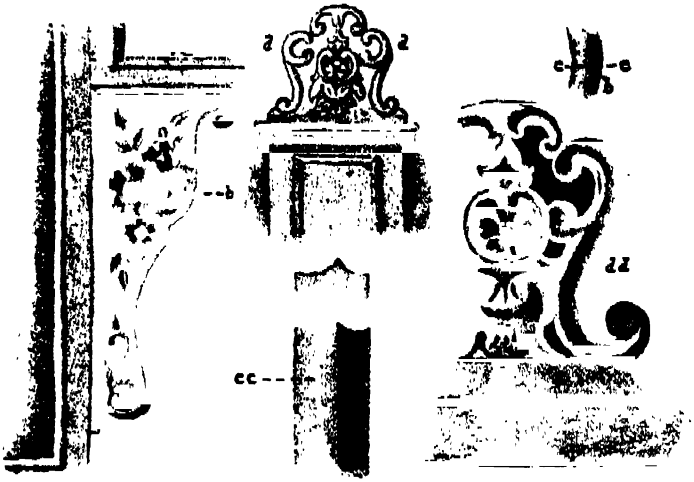


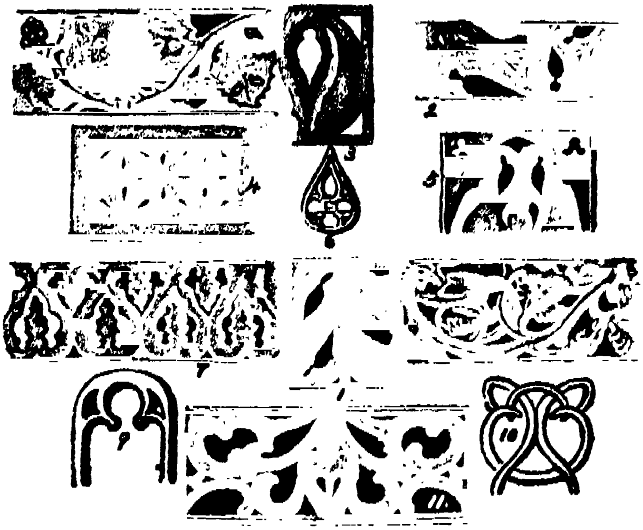
THE ORNAMENTAL DRAUGHTSMAN (*see Text*).



Block-out of Subject in Plate XXXIII.

ELEMENTS OF CABINET MAKING (*see Text*).





THE STONE MASON (see Text).

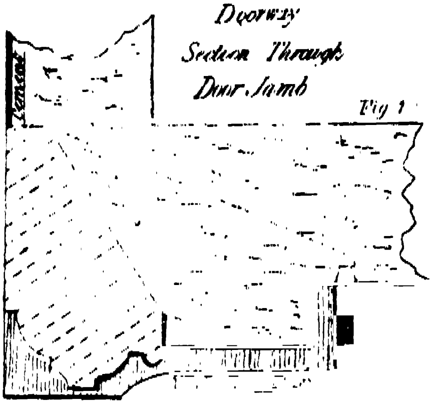

Doorway Section Through Door Jamb

Fig 1

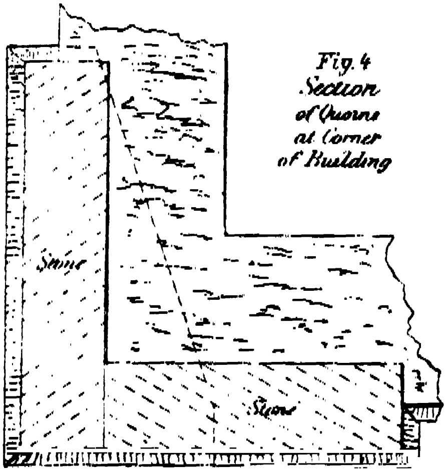


Fig. 4 Section of Quoins at Corner of Building

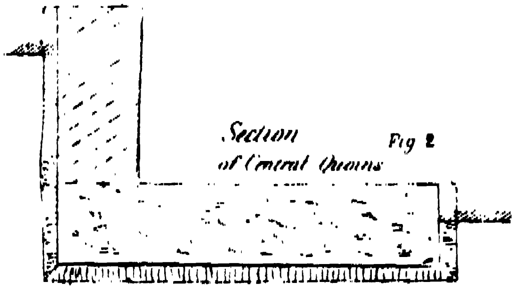

Section of Central Quoins

Fig 2

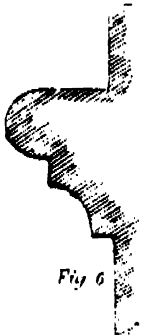


Fig 6

Window String ½ Full Size

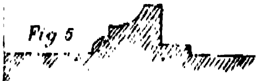


Fig 5

Window Architrave 1 in to a ft

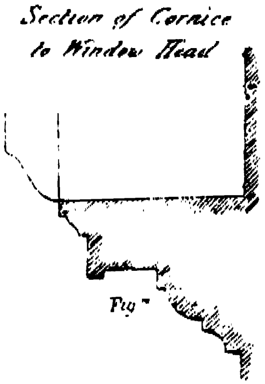

Section of Cornice to Window Head

Fig 7

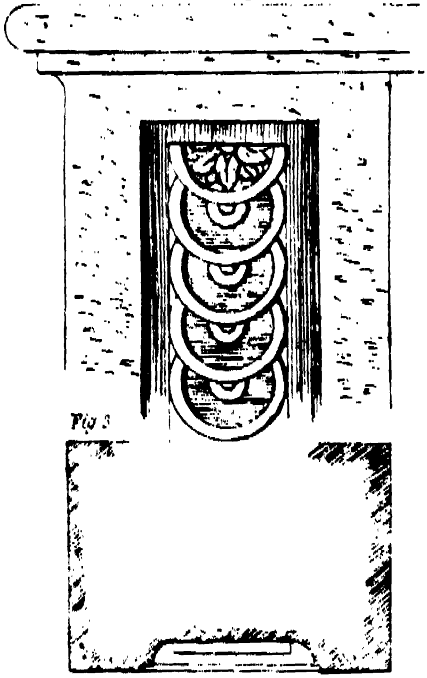
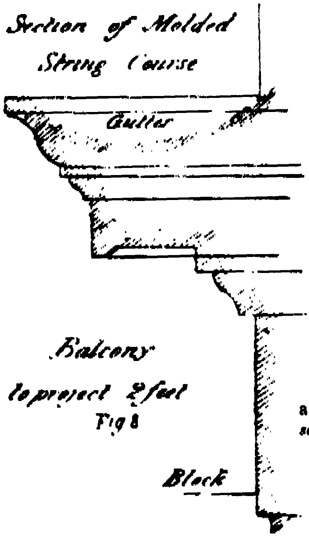

Part Elevation of Mullion

Fig 3

Stone Window Mullion ½ Full Size



Section of Molded String Course

Balcony to project 2 feet

Fig 8

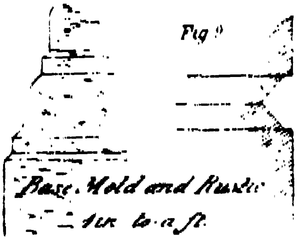


Fig 9

Base Mold and Rustic 1 in to a ft.

Details of House, Plans of which are given and described in Text—see "The Domestic House Planner."

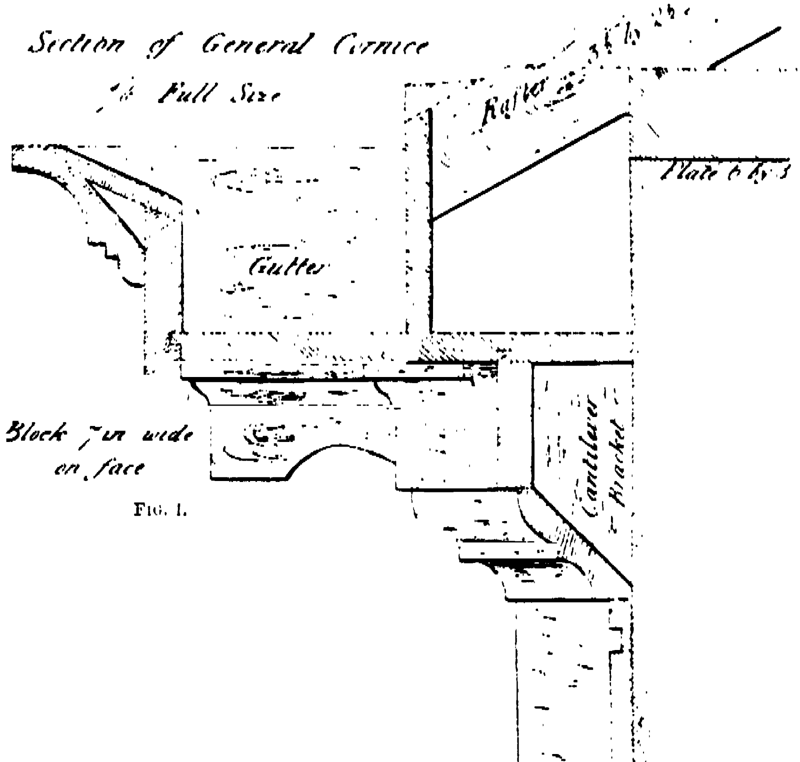


FIG. 1.

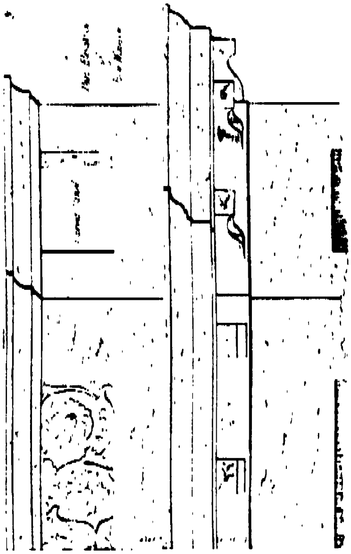


FIG. 2.

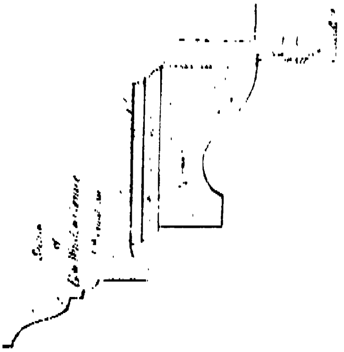


FIG. 3.

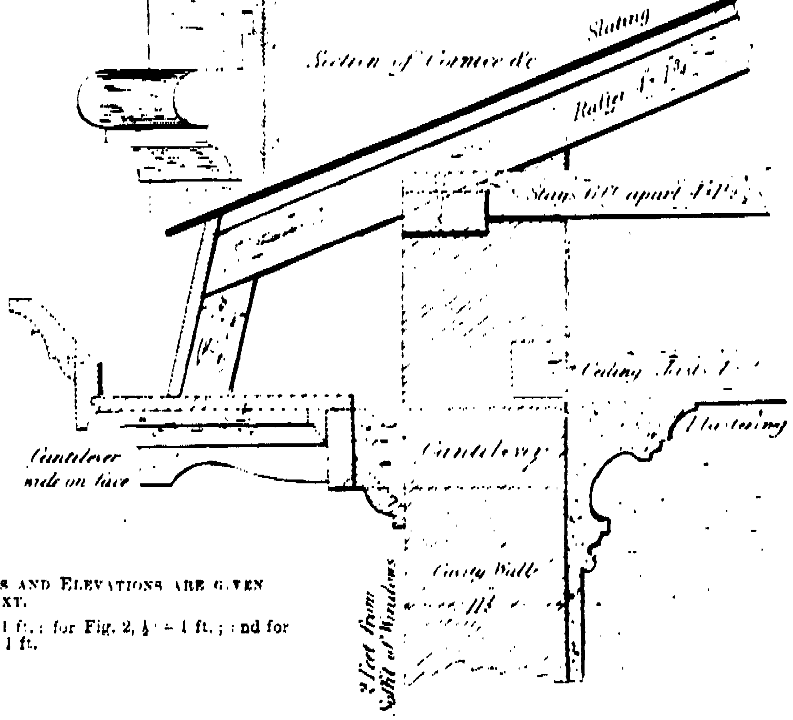


FIG. 4.

DETAILS OF HOUSES, OF WHICH PLANS AND ELEVATIONS ARE GIVEN IN THE TEXT.

Scale for Fig. 1, 2" = 1 ft.; for Fig. 4, 1" = 1 ft.; for Fig. 2, ½" = 1 ft.; and for Fig. 3, 1½" = 1 ft.

THE ORNAMENTAL WORKER IN METALS (see

THE ELEMENTS OF ORNAMENTAL IRON-WORK.

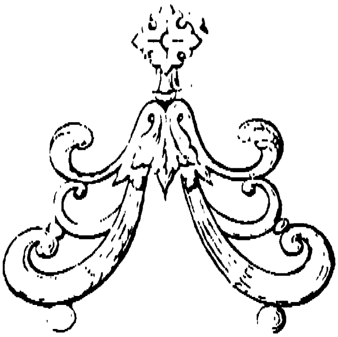


FIG. 1.

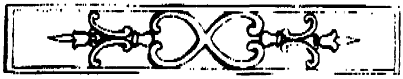


FIG. 2.

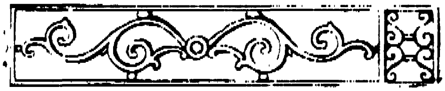


FIG. 3.

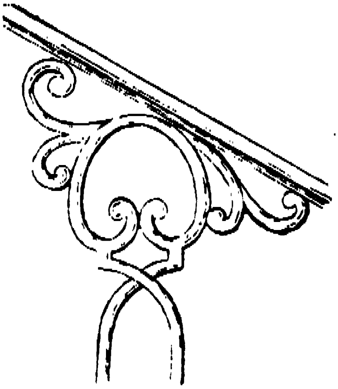


FIG. 4.

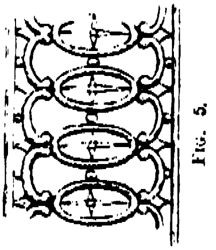
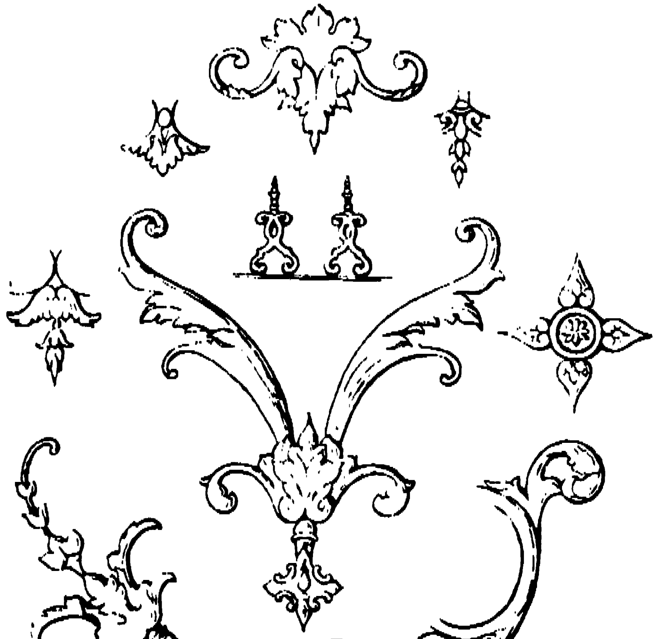


FIG. 5.



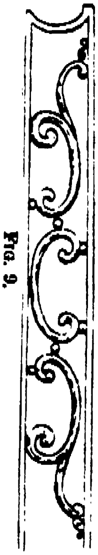
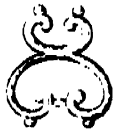
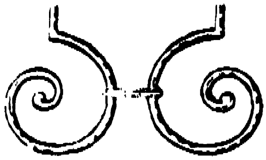


FIG. 9.





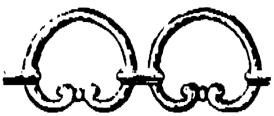


FIG. 6.

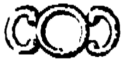


FIG. 7.

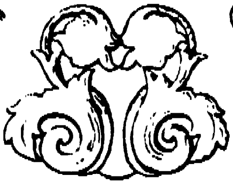


FIG. 8.

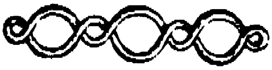


FIG. 10.

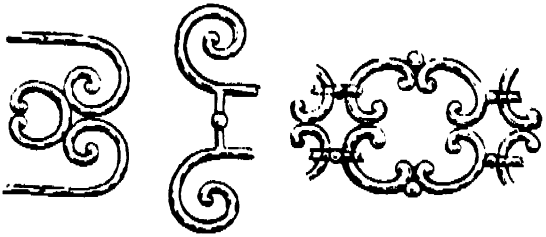


FIG. 11.

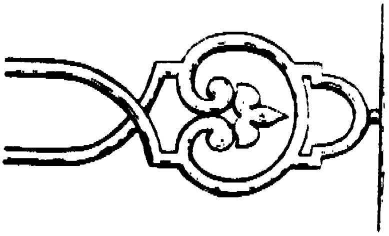


FIG. 12.

THE BRICKLAYER (*see Text*).

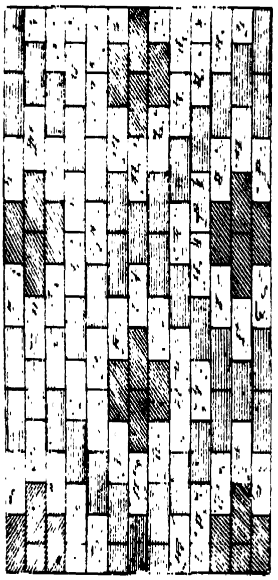


Fig. 5.

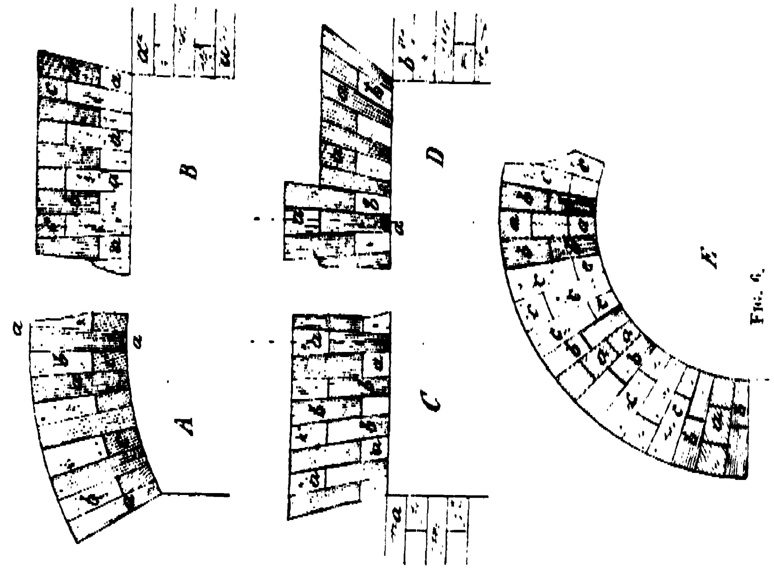


Fig. 6.

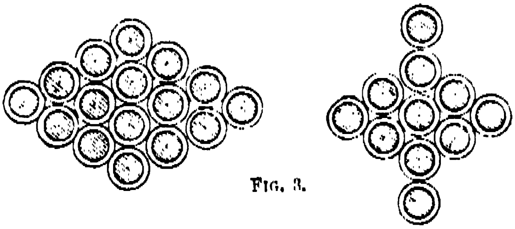


Fig. 3.

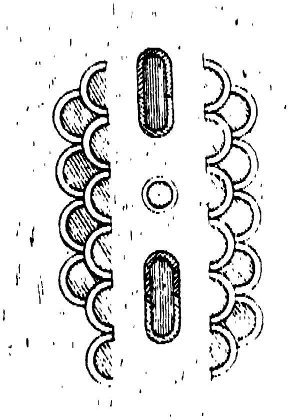


Fig. 4.

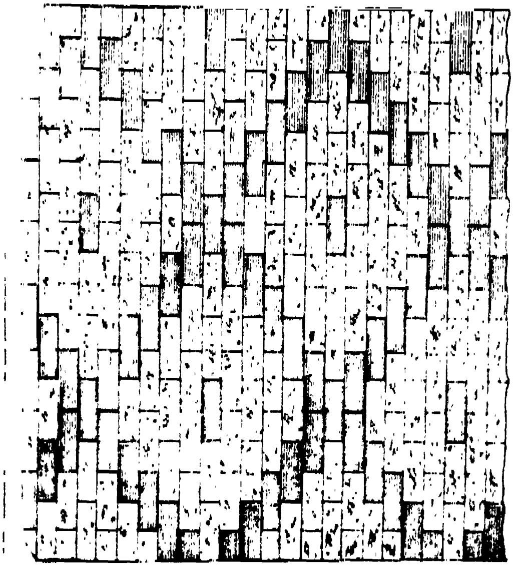


Fig. 1

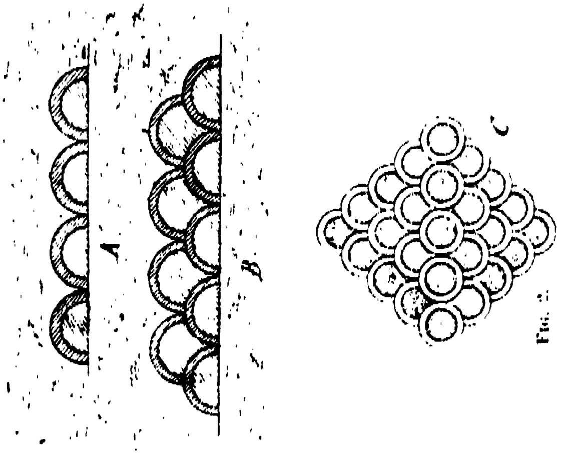
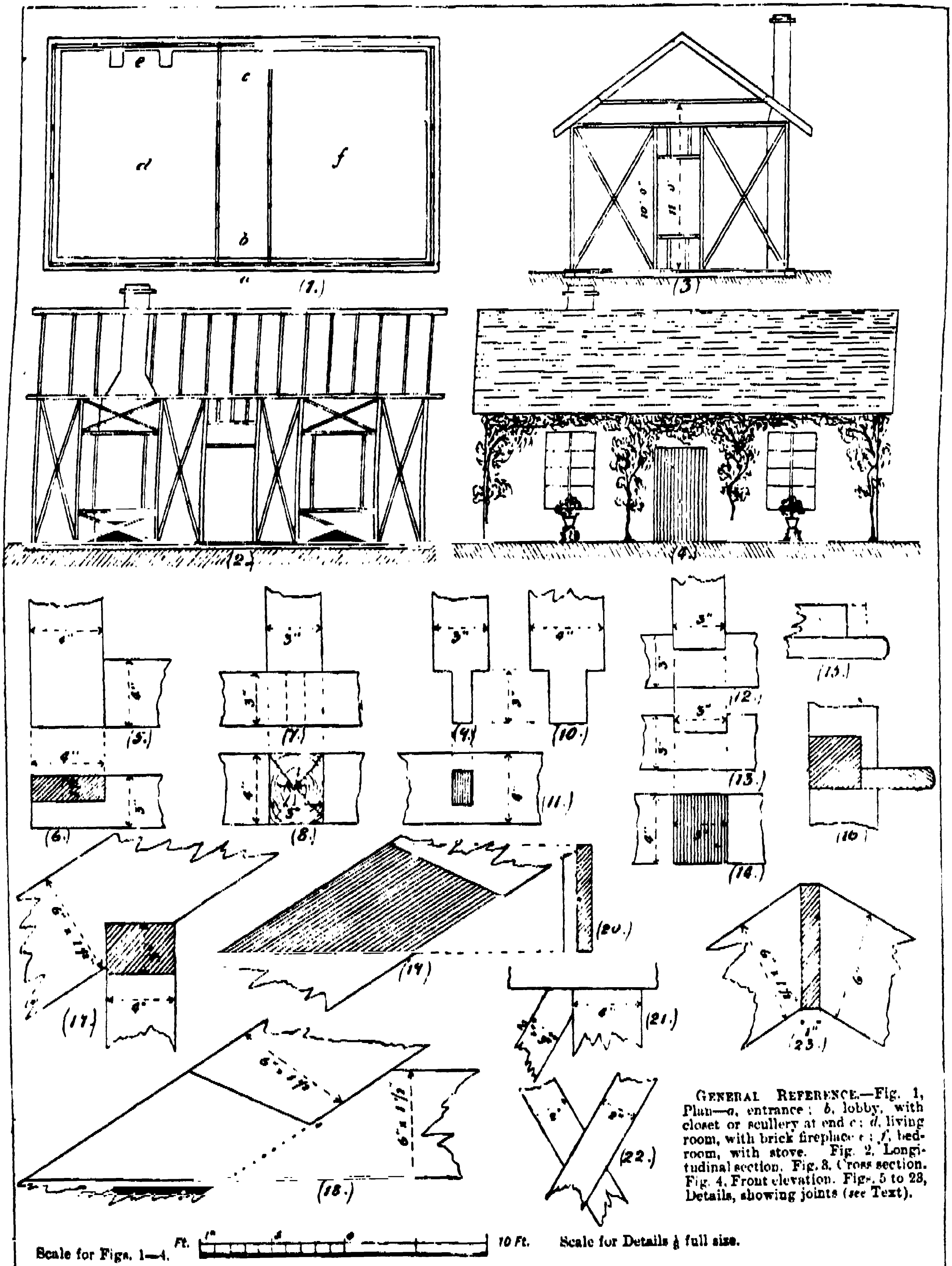


Fig. 2.

THE CARPENTER (*see Text*).

TIMBER COTTAGE—OR "FRAMED-HOUSE"—FOR COLONISTS AND EMIGRANTS.



Gᴇɴᴇʀᴀʟ Rᴇꜰᴇʀᴇɴᴄᴇ.—Fig. 1, Plan—*a*, entrance; *b*, lobby, with closet or scullery at end *c*; *d*, living room, with brick fireplace *e*; *f*, bedroom, with stove. Fig. 2, Longitudinal section. Fig. 3, Cross section. Fig. 4, Front elevation. Figs. 5 to 23, Details, showing joints (*see* Text).

Scale for Figs. 1—4.

Scale for Details ½ full size.

TECHNICAL EDUCATION

IN RELATION TO

THE PRESENT CONDITION OF OUR INDUSTRIAL WORK.

CONTENTS.

Value of Graphic Illustration in Technical Education—The Drawings and Designs a Special Feature of *The Technical Journal*—The Merely Pecuniary Advantages accruing to Working Men from Technical Knowledge, an Important Point in Relation to a Practical Work like *The Technical Journal.*—Value to Workers in Special Branches of a General Knowledge of other Departments of Technical and Industrial Work—Claims of *The Technical Journal* upon the Attention of the General Reader—A Knowledge of Technical Work an Important Part of a Modern Liberal Education, apart from the Inherent Interest attached to it Nationally—Direct Pecuniary Value of *The Technical Journal* to Special Classes of the General Community—*The Technical Journal* as it appeals to Youth, and as a Text-Book in Elementary and Advanced Schools—The General Characteristics of *The Technical Journal*—Grouping or Classifying the various Branches of Technical and Industrial Work.

Value of Graphic Illustration in Technical Education—The Drawings and Designs a Special Feature of "The Technical Journal."

To another feature of permanent practical value we deem it our duty specially to draw the attention of the reader. While the principles and practice of the various technical trades and industrial processes will be explained by a wide variety of facts drawn from practical experience, it is obvious that, dealing as many of them do with, and dependent as they are upon, principles of those sciences upon which geometrical and natural forms, constructive details, and mechanical arrangements of all kinds are based, the aid of graphic illustration must of necessity be called in. Where so many problems are to be solved, so much of form, shape, or configuration to be shown, so much in the way of mechanical construction and arrangement to be explained, the work of the draughtsman must be given to aid and largely supplement that of the describer or writer. Without drawings, indeed, written descriptions would obviously be useless. There are many artistic and decorative forms and mechanical and constructive bodies which could not possibly be understood by descriptive words alone, however full and clearly stated: while if some are capable of being explained in some measure by words only, this explanation would to the great majority of readers be so obscure as practically to be of little value to them. Impressed with the importance of these considerations, and having the advantage of a wide and thoroughly practical experience of the subjects treated, the conductors and writers in their varied departments have paid special attention to the department of ILLUSTRATION. The best evidence of this will be met with in the pages of the work itself. It is not in the language of a prospectus, which is sometimes apt to be overstrained or exaggerated, but is the simple statement of a fact, when we here state that these pages will display, in their completed condition, an amount of illustration which, if it has ever been before equalled in preceding technical or practical literature, has not been greatly, if ever it has been, excelled.

But it is not merely in the fact that the illustrations will in mere number be great, that the value of this department will be displayed. This will lie as much, if not more, when their positive value is considered, in this—that a very large proportion of the subjects will not be mere designs, but will possess all the practical value of working drawings and lines applicable to nearly every branch of technical work. For a long series of months a staff of thoroughly practical designers have been engaged in the production of technical working drawings, specially arranged for the purposes of the work. The result of these labours will be seen in the many hundreds of illustrations with which it will be enriched.

The Merely Pecuniary Advantages accruing to Working Men from Technical Knowledge, an Important Point in Relation to a Practical Work like "The Technical Journal."

The publishers believe that it is impossible to overestimate the advantages which a work, carried out on the lines to which the conductors have given careful thought, must possess to all those interested in the progress and the future welfare of those technical trades and industrial processes upon which our national prosperity so obviously depends. The mere pecuniary advantages accruing to a technical worker from a knowledge of the principles upon which his work is based, and how best to apply them to its practice, is a point which must not here be overlooked. It is worthy of special note here that a knowledge of design—using this term in its fullest and widest sense, as including the ability to draw—is necessary in almost every branch of technical trade and industry. It is difficult indeed to name the value of this knowledge as directly and pecuniarily influencing the technical career of the workman. If he be ambitious to occupy a high position in his calling for his ability in designing—which naturally leads to and greatly helps his skill in construction—he must thoroughly master the principles of design in the constructive, mechanical, and decorative arts. For this ability in technical education lies at the very base of all progress—without it none can be made. No doubt it may be said that the ability to design or to invent, no less than the handicraft skill to construct, may be both possessed by a man who is not educated highly—not, in point of fact, "educated" at all, meaning by this term the possession of the ordinary and even of some of the higher branches of acquired knowledge. But while this cannot be disputed, it is easy enough to perceive that, valuable as these faculties are, even in the case of the non-educated man, their value would be greatly increased, if to them he could add the powers which acquired knowledge of true, that is scientific design, would give him. To those who will not concede this, to those who believe that education or the possession of acquired knowledge has not a true practical or money value, what might be said on this subject possesses no interest. We should be glad indeed if it would really concede them, for then some benefit would flow to themselves from their anxiety. But we may very reasonably conclude that the readers we are now addressing do not belong to the unfortunate category of those who see no good in, certainly no pecuniary or trade value attached to, technical knowledge based on sound because scientific principles. For it may be safely assumed that their very reading of these pages presupposes their desire to learn something, so that they do not require to be convinced of the benefits—directly pecuniary as they in some of their aspects are—arising from the possession of acquired knowledge bearing upon their technical callings or trades. It is the very aim of our work to impart this knowledge.

The conductors feel, therefore, that they are fairly entitled to claim for the work, of which the foregoing gives but some of its many features, a practical value of a specially important character. It will serve the highly useful purpose of giving in clear and intelligible language, aided by all the fulness and completeness of graphic illustration elsewhere alluded to, the practical details of the leading handicrafts and trades with which the industry of man is concerned. They are also prepared to insist upon this—that it will give to those actually engaged in the various branches of industrial work a positive power calculated directly and immediately to raise the value of their work. It will thus conduce to those pecuniary advantages which it is the legitimate ambition of all to obtain from their labour. And to do this something is now wanted, more than what the requirements of former times demanded. Then we had the practical monopoly of the trade of the world, and it was considered enough if the worker could turn out the products of his trade perfect as mere examples of handicraft skill. But while this is still, and always will be required, and while there is every reason to believe that we shall in this respect maintain the position we have secured,—nevertheless, if we are to maintain our supremacy as the producers of the world's "goods," something more is wanted than the mere skill of the hand. It is necessary now that our workmen shall, in addition to the possession of this manipulative dexterity, add a thorough knowledge of the materials in which they work, their capabilities and possibilities—and more than this, an equally complete acquaintance with the principles upon which their work is based, and of those upon which it is designed. To the mere skill of the hand, for which we have been so long and so deservedly celebrated, we are required now, by the demands of the new times we live in, to add the knowledge of the head. To practice we must now add science, for it is not a mere opinion, but a stern fact, that for lack of the higher elements of knowledge, some of our trades have already suffered severely, and much of their paying business has been taken up by foreign competitors. If those have not as yet produced work so well made as our handicraftsmen have done, they yet have excelled us in the higher branches of a knowledge of scientific principles, and especially in design. And we have seen that the main incitement to the movement, of which every one has recently heard—namely, the establishment of technical colleges, institutes and classes, having for their object the teaching of our working men in the higher branches of work—is this very circumstance of the serious nature of the losses incurred by certain of our trades, in consequence of our workmen not possessing the same higher knowledge which it has been the aim for a long series of years of many Continental countries to give their workmen. It is thus true, beyond all doubt, that if we are to hold our own, our workmen must determine that they at least shall not fail to acquire that knowledge which assuredly pays directly and indirectly. And it is as being so well calculated to give them a direct help to this, that we claim for our work that high position which carries with it a practical value in directly advancing the pecuniary interests of those who consult its pages. It has ever been the truth that a workman who knew most advanced the most quickly in the receipt of higher wages, and to that improved social position which is always the reward of higher pay judiciously and wisely expended. But hitherto these "knowing men" have been but rarely met with: certainly they have formed but a small percentage of those engaged in industrial work. They are, however, daily on the increase, and just in proportion as their numbers increase, so will the value of our national work increase also, and its power to meet with fearlessness, because it will be able to meet with success, the competition of peoples other than our own, from whatever quarter of the globe it may come. The best thinkers amongst us are clearly of opinion that we have nothing to fear from foreign competition, if only our workmen will decide to know the best—and this the most—of which their work is capable. To do this will doubtless demand study, and a sacrifice in some, if not indeed in many, ways. But we are of those who believe that this study will be readily given, those sacrifices cheerfully made. And this hope we base upon our knowledge of our workmen, who have as yet ever responded to all appeals to rise to the dignity of appreciating the importance of all positions which closely affected their interests. And this appeal comes to them fortified by one of the most vital, the gravest indeed of considerations, affecting as it does, if not the very existence, assuredly the money-making value of their varied callings.

Value to Workers in Special Branches of a General Knowledge of other Departments of Technical and Industrial Work.

But it is not enough that our workmen should thoroughly know the materials upon which they are employed, and the principles upon which their work is based and designed—in brief, that they should know all that their best interests demand them to know about their daily calling. It is also to a large extent an essential part of their training in the study of the home that they should know, if not thoroughly, at least a good deal about, the work done by their fellow-workmen. While the workman will make, as he ought to make it, his first duty to master the full details, both in principle and practice, of his own calling, so that he will become a valuable "specialist," worthy to receive the highest wages of his trade, he will, if wisely making the most of his opportunities, devote some time at least to learning what other workers are doing, and what are the peculiarities of the practice and the leading points of the principles upon which their work is based. It is a grievous mistake to suppose that any trade or calling can yield no hint or afford no help to another. If space and the present place permitted, we could cite numerous instances where one worker has derived hints of great pecuniary value from another. And this has frequently happened although the peculiarities of the two trades were such, and so dissimilar, that at first sight it would have seemed right to conclude that the one could not possibly give a hint or help of any value to the other. But more than this can be said in favour of the wider study we here refer to. For it enlarges the mind, and strengthens and invigorates the thinking faculties, and beyond all question it places the man upon that higher platform which the possession of varied attainments always gives him. "Learn everything you can, my boy," said a sage and most successful man of business. "You may not get an immediate use for it, but it costs nothing to carry with you wherever you go, and the place and time will almost surely come, when you will find that it will be useful and put money in your pocket. Gain experience—fill your head with knowledge; it will help you to fill your purse, my boy."

Claims of "The Technical Journal" upon the Attention of the General Reader. A Knowledge of Technical Work an Important Part of a Modern Liberal Education, apart from the Inherent Interest attached to it Nationally.

It is partly in this, but chiefly in a more direct way, that we claim for our work a further and a wider utility than we have yet named for it. We refer here to its value as a book of specially useful reference to the *General Reader*, who may yet not be directly connected with any of the branches of work of which its pages give a special treatment. The desire for knowledge of all kinds has been such a marked feature of late years that cultivated men are expected to have at least some knowledge of the arts, sciences, and trades, which have ministered so powerfully to our national greatness. And to those who possess something more than a mere passing acquaintance with their details, and can give when required something of an authoritative opinion upon them, a position in society is accorded which denotes the high value it places upon knowledge of this kind, and which, while it is gratifying to, is deservedly gained by, its recipient. And it is moreover nowadays very hard to say when a man may be placed in such circumstances as may give this knowledge a direct pecuniary and business value.

Other Directions in which a Knowledge of the Details of Industrial Education is Useful.—Masters and Managers.

No doubt the actual workers constitute the greater factor in the question of industrial education, as they form by far the greater number of individuals interested in the maintenance of what is called "good trade." But they are not the only members of the community who are interested in this matter of vital importance to us as a people. The masters have an equal interest with men in the right solution of this great question connected with it—namely, how best and most quickly to carry out a scheme or system by which we shall retain the trade we at present possess. This dual relation of the two classes, the employers and the employed, must not be lost sight of in considering the details of the general question. And although it will be gained in a different way, and be arranged upon different lines, the *industrial education* of the employers, or of those who, yet young, are likely to be such when they have entered on life, must be carried out as carefully and energetically as the industrial education of the employed over whom they are placed. These will act and react upon each other, dependent upon the way in which the dual relationship is maintained, either for good or evil. It is folly to suppose that, if simply let alone, this relationship will somehow or other simply adjust itself. And if education be insisted upon as essential to the workers who are led or directed by the masters or employers, surely education is required by the latter also.

The Relation of Masters and Managers to the Great Question of Industrial Education.

In one sense there is no class so deeply interested in the details of the great question of industrial education as the masters, for their pecuniary responsibilities are simply enormous, and with them a retention of such trade as we at present have is simply a matter of the highest necessity. For this question of foreign competition this "terrible battle of competition," as Professor Huxley, the eminent scientist, calls it—is, to use his words, "no transitory phenomenon, and does not depend upon this or that fluctuation of the market, or upon any condition that is likely to pass away." So potent is this condition that, in the opinion of the same eminent authority, who is not likely to take other than a calmly dispassionate view of the case as it stands, we are only saved from a social catastrophe—the impossibility of feeding our vast industrial population—"solely by our possession of a fair share of the markets of the world." And if this "fair share" can be maintained—if not solely, at least largely—by our workers having a higher knowledge than the great majority of them at present possess of the principles upon which their work is based, and a greater degree of intellectuality generally, surely it is unnecessary to dwell here upon the responsibility which rests upon masters, and in another but still important direction upon managers, in the matter of becoming acquainted with the details of the industrial education which is to be so necessary to those under them, and the relation the system bears to themselves, who have all the administrative and executive work of factories and workshops devolving upon them.

A Practical Acquaintance with the Principles and Details of Industrial Education Essential to Managers of Industrial Concerns.

It is impossible to overestimate the value of good administration and the good management of a large factory or works, and the difference between the two must be noted: it is one thing to administer, another to manage. And although the work of administration—of arranging the system of working, say, in a large spinning mill or a manufacturing concern, and of afterwards managing it—that is, seeing that the details of that system are carefully carried out—is often done by the same individual, it by no means follows that the talent for designing or planning, so to call it, of the system, and the skill in looking after its details, so that they be done in unison with it, are identical. A man may have skill enough to make a machine well who could not move a step towards the designing of it, nor have the talent to invent it. So a man may not have the talent, the experience, the far-seeing capability to provide for a variety of possible contingencies to devise a system of working, yet may have the necessary qualifications to see that the people employed in carrying out its work shall do this in the best and most economical manner. On the other hand, a man may have the talent of designing, thinking out of a scheme, of perfecting a system of administration, and yet fail in those habits of action, of feeling, of tact, which go to make up a successful manager of men and of materials. It is not a difficult thing to find within the ranks of business men, those who like and have the aptitude for the administrative, yet do not at all take to the executive part of work—and this not seldom from their idiosyncratic dislike to have close personal dealings or relationships with men, from their ignorance of their habits, modes of thinking and of acting, as well as from their ignorance of the finer details of actual working of machines, processes and the like. That a vast deal or large amount of the success of a concern depends both upon its administration and management; and of the two, if one is more important than the other, the more important is the management. Indeed, the difference between a concern which is a success, and another the reverse of this, is generally the difference between *good* and bad management, not that between a good and a bad administration or system of working. A great many qualities must be combined to make a good manager—not merely a general knowledge of the machines or processes which form the work of the concern over which he presides, but a thorough acquaintance with the principles upon which these are based, with the materials used in the work, and with the market or commercial points connected with them. But a still wider, and in many respects a higher, certainly a more difficult, range of duties awaits the manager in his endeavours to be a thoroughly competent and a successful one. These duties lie in relation to the "hands," the men with whom he has to work and who have to do his work. This relation tests a manager much more crucially than do points more closely connected with the actual work. And if a successful manager were asked what part of his work occupied the most serious of his thoughts, demanded the most anxious of his cares, gave him the most difficult problems to solve, it would not, we venture to affirm, be the technical department of his work, but the *management* of the hands, and the various details of this difficult department which would occupy the major portion of his reply. In this department many qualities are demanded from the manager, some of which are not always combined in the same individual, but have to be acquired by long and patient practice from the lessons of a sometimes painful experience. For its chief difficulties lie in the fact that that singular factor in life—

human nature—has to be dealt with. The most complicated of mechanism or of processes, the most refractory material with which he has to deal in carrying out the practical work of the concern, is facile and easy of management compared with the ever varying, always more or less puzzling individual characteristics of the "hands" over whom he is placed in authority, and upon whom he is of necessity compelled to depend in getting the work of the establishment carried successfully through. Tact, prompt decision, firmness of will, yet a thorough kindliness, which takes cognisance of the sympathetic, the human side of the men he deals with; high morals, and a stern sense of justice which will carry with it the conclusion that his decisions will be characterised by the quality so dear to Englishmen—"fair play": all these attributes and qualities will find in the details of a large concern a wide field for their exercise. And although much of the knowledge and many of the qualities essential to the making of a good manager can only be learned by the actual practical training early begun and long prolonged through the daily work of a factory or workshop of the same kind of which he aspires to be some day a successful manager, still such an one, aiming at so useful a life and work as this, will beyond all doubt derive much benefit from the results of private study. The writer of these lines has availed himself of every legitimate opportunity to point out the importance of what he deems to be a valuable practical truth—namely, that, apart altogether from the details of technical education as they concern our workmen, a vast amount of the future of our manufactures depends upon what during the next few years will be the action of the masters, the heads of the concerns—this term being used here in its widest acceptation, as including managers and the higher class of foremen. And this opinion the writer has formed as the result of a fair amount of practical knowledge of the class or classes, and of what has been and what is now the position they occupy in relation to the practical work of our industrial trades and callings. Some practical knowledge also of the working-classes, the "hands" of foreign countries, has in this connection led the writer of these lines to the conclusion that the workmen of this country have no great if indeed any reason to fear the competition of their fellow-workmen on the Continent. No one who, like the writer, has an actual acquaintance with what some of the most important departments of industrial work are, but must have been struck with the difference between the workmen of the Continent and those of our own industrial concerns. Some authorities who, from their experience of the actual circumstances, have certainly a right to give an opinion on the subject, maintain that a British workman is quite equal to two German workmen—taking this nation as representing if not the keenest certainly the ablest of the foreign competitors with our trade. While we might hesitate to indorse fully this opinion, there can be no doubt in the minds of those who know what the two classes of workmen are, and what the quality of the work they respectively turn out, that the British workman is far ahead of his German competitor. We might, did space permit, run over a number of facts in proof of this; but to one department we may confidently refer as affording a striking proof of the truth—that is, the department of machine-making or general mechanical work. Here, beyond all dispute, the British machinist occupies a position so far ahead of all his competitors, that it will be wholly his own fault if he allows them even to approach it. All this is true of the relative position of the British and the Continental workman, and is corroborative of what we have above stated—namely, that while the British workman has apparently less to fear from Continental workmen than some seem to have concluded, this is not true of the British masters and managers. It is fast becoming a conviction in the minds of the far-seeing amongst our practical authorities, that the real, at all events a very great, danger lies in the fact that they—the masters and managers—will fail in the keen competition with their brethren. We believe that a full investigation of the position in this country would go far to show the truth of this. The Royal Commissioners who were appointed to inquire into the condition of technical education in this country and on the Continent seem to have been most deeply impressed with this department of the general question, as will be seen from the following extract from their report, to which we beg the earnest attention of our readers. The Commissioners say that they "*cannot repeat too often*," so impressed have they been with the vital importance of the subject—they "cannot repeat too often, that they have been impressed with the general intelligence and technical knowledge of the masters and managers of industrial establishments on the Continent. They have found that those persons, as a rule, possess a sound knowledge of the science upon which their industry depends. They are familiar with every new scientific discovery of importance, and appreciate its applicability to their special industry. They adopt not only the inventions and improvements made in their own country, but also those of the world at large—thanks to their knowledge of foreign languages and of the conditions of manufacture prevalent elsewhere." In other directions Continental masters and managers are ahead of the like class with us. They are ahead of us in the way in which they find out new markets for their goods, and, what is of equal importance, in the way in which they adapt themselves to the habits of the people they trade with. The Commissioners on Technical Education note with high approval their painstaking, their pliancy, their greater thrift, and their cultivation of modern languages and of economic geography, as elements in the success which meets the efforts of our Continental competitors. We have thus clearly shown the importance to masters and managers of a knowledge of technical subjects. While the young manager, therefore, is careful to acquire all which a painstaking practice will give him, it will be well if, while he is passing through the years of his early probation in the works, learning all which will be of service to him when he assumes the office of a manager, to which when young he aspires, he bears in mind the truth of the saying of a great and successful man, himself a splendid example of the effect of careful training and of *home study*, that "all knowledge lies hid in books." And although these pages would be the last in which book study would be placed as first in importance, to the exclusion of that practical training in the workshop or factory without which technical or industrial education would be practically useless, still it must not for a moment be forgotten that the knowledge which does lie hid in books is the basis on which all practical work rests, by which its principles are exposed, and in which its best work is recorded. The knowledge which lies hid in books is simply essential to the man who wishes to be thoroughly informed in all departments of industrial science; and in a work like the present, which is specially designed to be a guide for home study, embodying the principles upon which the best practice is based, it is scarcely necessary to say more as to its importance. To such, then, who are looking forward to be managers of large industrial concerns, the conductors of the **INDUSTRIAL SELF-INSTRUCTOR FOR HOME STUDY** venture to believe that, although not prepared with direct or special reference to them, still, within the range of the subjects it treats, no small amount of knowledge useful to them will be found: *e.g.*, in this present paper, and in those entitled "The Workman as a Technical Student," "The Introduction to Mechanics," "The General Machinist," "The Ornamental," "Machine," and "Geometrical Draughtsman."

THE ORNAMENTAL DRAUGHTSMAN.

His Study and the Details of its Practice, chiefly in Relation to Technical Work in Manufacturing Design.

CHAPTER V.

Recapitulatory Remarks on the Foregoing Elementary Lesson in Straight and Curved Lines.

Let us, before dismissing these early or rather earliest lessons of the young ornamental draughtsman, pass briefly in review what we have already accomplished. The result may be stated in few words. The pupil can now draw a straight line, and he can draw a curved one. Now, as these are the only lines possible—for an irregular line is but a combination of straight or curved lines, or both—he has acquired what has at any rate something of importance about the art of ornamental drawing. Let the pupil consider that the application of these two classes of lines—the straight and the curved—are practically infinite. From the endless objects of nature down to the slightest carving of the chair on which we are sitting, does their power of expression range! Every class and style of architectural work — Egyptian, Greek, Roman, Moorish, British, Classical, Gothic or semi-savage, with their infinitude of tion—are all representable by these two species of lines! In a word, the whole temple of Ornamental Drawing is now open to the pupil, and he has with him a key which will unlock its doors and admit him to its apartments, however seemingly dissimilar they

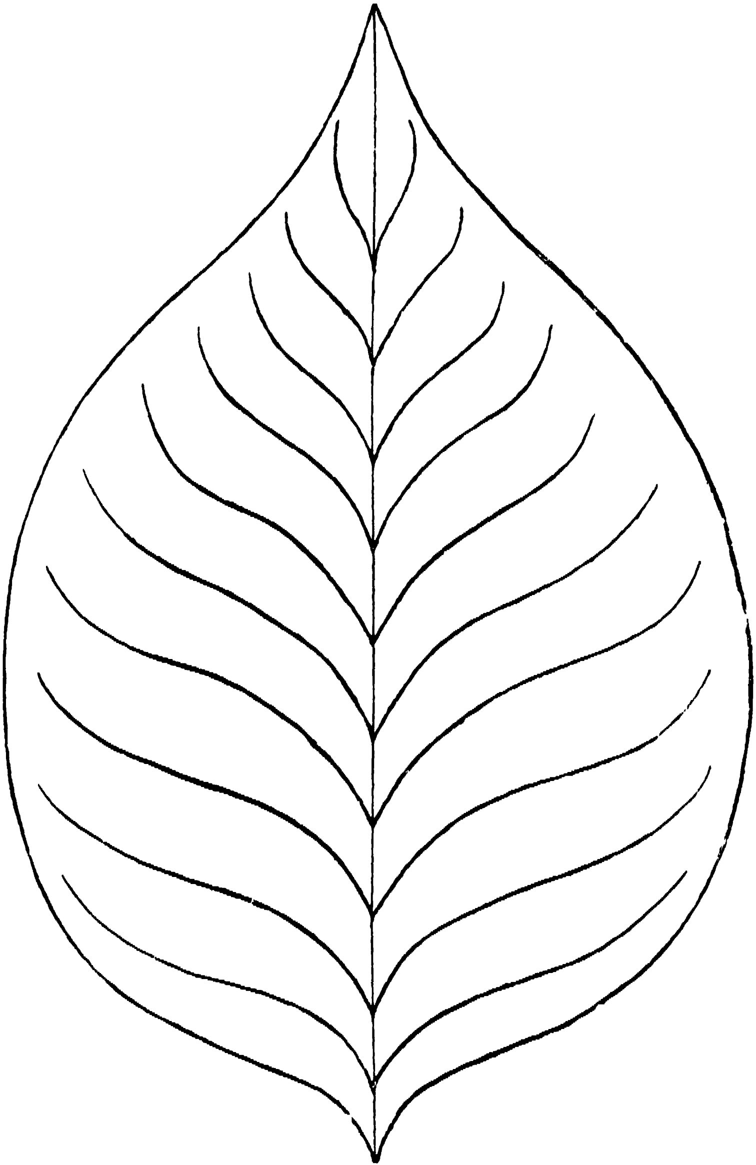


Fig. 24.

may be. This labour of his has not been in vain. Rather in truth has it been essential. For it has given him a potent power, with only the trifling inconvenience of struggling and disappointment and occasional downheartedness through which he has gone. The healthy working influence of this wholesome "drudgery" or "apprentice work" he has gone through will be felt during the entire course of his artistic career, and it will be with something of satisfaction that he is able to recollect that he had the good sense to "begin at the beginning," and do its hard work patiently and with a thorough determination to do it well.

Fig. 24.

Do not, however, let him delude himself with the notion that he has accomplished everything required to make him an able ornamentist. He has simply begun to *know*; and although he has an accurate knowledge of the alphabet of the art, and can form its letters into simple words, the boundless field of its diversified literature, so to say, still needs exploring. To use the illustration before given, we have placed the pupil on the threshold of a splendid temple, and handed him the key of it. It is on himself now, principally, that the work of progress must fall. It is his own powers of observation, aided as these must be by the cultivation of the accuracy of the eye and the dexterity of the hand, which must mainly guide him. In the examples which will follow in succeeding chapters, he will find a much fuller development of the instructions which have been already laid down. And these examples we commend to his careful consideration and diligent copying, both as specimens which will afford him good practice, and as excellent initiations into the purely technical work of ornamentation. The student will find the leading specialties of ornamental art, or the application of ornament to the various branches of art manufacture, discussed in the paper under the head of "Form and Colour in Industrial Decoration," and in the papers supplementary to this, which take up the subjects of "Ornamental Work in Wood, Stone, Terra Cotta, and in Iron," and in that which takes up the subject of "Mouldings."

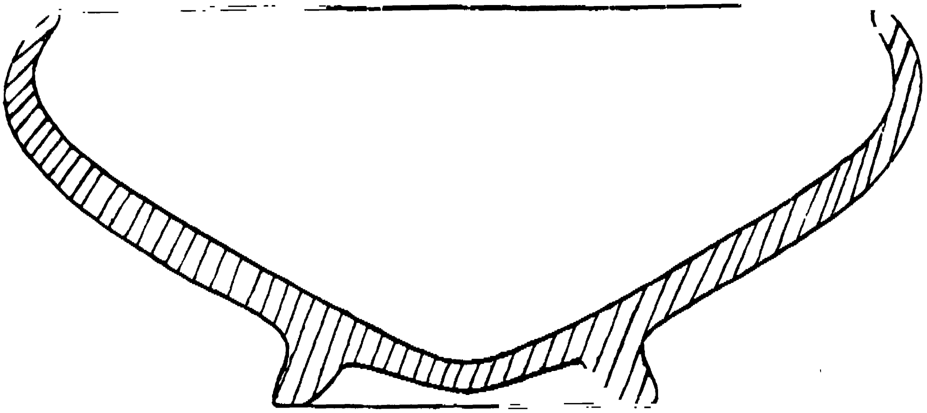


Fig. 25.

Subjects for the Student to Copy.

We have just stated that we should give various drawings which, as examples, will be necessary for him to master in order to give him that facility for "copying" which is the first essential in "designing." But those drawings which we now proceed to place before the pupil, while they have this essentially useful purpose, are prepared with another view—namely, to communicate to him a knowledge of the leading characteristics of the chief styles of ornamentation. The whole have been carefully designed and prepared specially for the pages of this work. And this much at least may be said for them: that they are the outcome of such practical experience as is likely to be obtained from the work of a lifetime devoted to the teaching of design, with special application to what is now widely known as Art Manufacture.

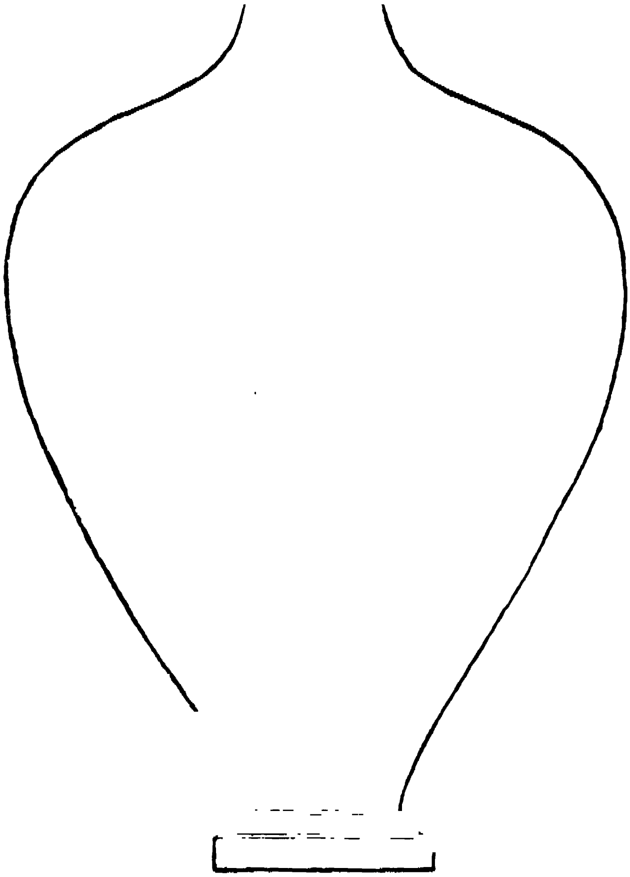


Fig. 26.

The lines which the student has hitherto drawn were what might be called elementary lines of ornament. We shall now proceed to draw "form," or apply the lines to the shapes of objects. The first is a conventional form of a leaf (fig. 23). After drawing the shape, making both sides equal, the student will then carefully draw the veins, and balance them, making both sides equal: this is very essential. Following the last figure, the student will draw very carefully this Cypro-Phœnician wine cup, in fig. 24 it is drawn the same size as the original, from a cup made three thousand years ago. The student will observe how the lip turns in, to prevent spilling. We have drawn in fig. 25 the section, in order that he might see the inside shape, as well as the outside.

THE DOMESTIC HOUSE OR HOME PLANNER OR DESIGNER.

THE WORK OF THE YOUNG ARCHITECT OR BUILDER IN THE

CHAPTER III.

'"Storing Conveniences essential in every House," we ended our last chapter by stating that if we will persist in building houses without conveniences tending to minister to habits of order and what is called tidiness, it is folly to expect their occupiers to be orderly or tidy. We were about to say that it is not easy to be tidy when no means to secure tidiness are at hand; but the truth is, that it is practically impossible to do so. One cannot, like a Mahometan, wash with make-believe soap and invisible water. We may talk long enough as to the value in every household, however mean or poor it may be, of putting everything in its proper place; but it surely takes no great degree of wisdom to know that this cannot be done if there be no place provided for the thing to be put in. And yet how frequently do we meet with cases in which it is but too obvious that if this modicum of wisdom was possessed, it was not at all events made available, so far as the plan of the cottage gave any evidence. It may be well enough to talk of improvement of the habits of the lower orders, as they are perhaps somewhat too complacently called, but it is much better to see that we actually do provide them with the means of improvement. Does this all come about because to talk is so much easier than to do, or is it because talk of this kind is pleasing to our vanity? Possibly this last, inasmuch as it implies that we who denounce the home habits of the poor must, therefore, be on a much higher platform than they. Certainly we have been for the last fifty years at least indulging in much talk, both on platform and through the press, as to the essential importance of what we call sanitary improvements, and yet have done practically so little in securing them that we have scarcely begun even the simplest of its work. Hundreds of cottages and houses of the same class are being built every year, each one of which is characterised by an almost, some indeed by an absolute absence, of all those conveniences tending to promote that tidiness of home habits we talk so much of, and profess to be so anxious to see universally carried out.

Absence of Working Conveniences a Characteristic of even High-class Houses.

We have said that this deficiency in house accommodation as regards what are known as "conveniences," and which are absolutely essential to the attainment of home comfort and economically done household work, is chiefly observable in houses of the lower classes. But it would be quite a mistake for the reader, whom we suppose to be at present somewhat ignorant of the subject, to

deficiency does not exist in houses of a very much superior class. Even in the case of middle-class houses the conveniences are supplied only in the minimum way. There may be a few cupboards provided, which may serve either as places for storing away dishes, etc., when they are in the lower or working rooms, or in the case of the upper rooms as wardrobes. But these cupboards as a rule get made simply because the very construction of the house compels, as it were, such to be made or provided. We refer to the places or recesses for such cupboards formed of necessity by the projecting jambs of the fireplaces, which are so often met with in houses of the middle classes. So often met with there, inasmuch as it is more expensive to contrive the walls so that the projections demanded by fireplaces shall be, so to say, concealed within the wall—that is, the side of the room in which the fireplace is shall have no recesses one each side of the fireplace, but be of as uniform or unbroken a surface throughout its extent as any of the other walls.

Use of Fireplace Recesses as affording Spaces for Storing Conveniences.

The recesses formed in so many of the rooms of our middle-class houses, and, as it were, naturally provided, seem, so to say, to suggest as naturally that the best way to utilise spaces which go back from the general floor of the rooms is to fill them up with shelves, which will hold something. And this use of the spaces is so exceedingly obvious, that only the most careless of house planners and constructors would pass them by and leave them just as they naturally are. Some, however, do,—we should be within the mark when we say that a great many do,—and very hard indeed is it for some tenants to persuade their landlords to give them the extra conveniences which such recesses would afford if fitted up with shelves, either left open, as in the case of a sitting-room, to act as bookshelves, etc., etc., or enclosed with a door or folding doors, so as to act as close cupboards, in the case of a kitchen. We shall see afterwards how these recesses may be utilised, and so utilised as to afford objects which in a simple but effective way will add much to the decorative attractions of the room. This point, we regret to say, is by no means often thought of even in good houses of the middle classes; all that is thought essential being to leave the wall surfaces as bare and bald as possible.

Special Closets or Storing Conveniences Necessary in Houses.

But in using such recessed spaces as affording household conveniences in the way of giving places for storing up and putting things away, some house builders seem to have exhausted all their planning ability in this direction. And this not seldom, if one may judge from the fact that in a goodly number of the houses which they have planned and built, not a single closet, even of the smallest, has been arranged in their plan which could be used as a store for any one of the many classes or kinds of what are called household stuff or gear, which every house possesses. As for a "larder," or true "store closet," properly situated in a part of the house best calculated for convenience, and for keeping meat and provisions in good condition for as long a time as possible, such a contrivance seems to be utterly beyond the thoughtful or inventive capacity of some house planners. If to design a thing implies thought as to the purposes for which the thing is wanted – and this is assuredly what design is—then such house builders and planners have but little, if indeed they have any, claim to the title of house designers.

Convenient Arrangement of Store Closets and the like, Essential in Houses.

It is essential, then, in order that household comfort be secured, that every house shall have not merely such accidental conveniences as cupboards fixed in fire-place recesses for accidental, in a measure, we have shown them to be –but special places or apartments purposely arranged. And these must be in size and in number proportional to the size of the house. This, therefore, makes the rule applicable to the smallest house, in which comfort is just as necessary as in a larger one. But it is not only necessary that such places be provided in every house, however small, it is equally essential that such conveniences be *conveniently* placed. If not, they have no real right to be considered conveniences at all. For the work of a house has to or should be done not only in an orderly way, but done as economically as possible, as regards the expenditure of time that "commodity" the value of which is often talked about, but which is, nevertheless, not always considered as it ought to be.

Relation of the Working Conveniences of a House one to another.

Any arrangement, then, of home conveniences which involves the obligation to go over an unnecessary space of flooring, or of separating needlessly one room from another, shows that it is a bad or carelessly thought-out part of the planning. Conveniences, to be worthy of the name, should be close at hand when wanted, or where the exigences of the household work to be done demand. What, therefore, must that house planner have had in his mind as to the correct principle which regulates the arrangement and construction of house conveniences, when he put his larder or store-closet upstairs on the bedroom floor? We had little doubt, when we came across this "eccentricity of" house-planning "genius," that the builder did not designedly or purposely place what he called his larder or store-closet in this pleasant and profitable position. What happened, likely enough, was this. In planning out his house on paper, he had come across, so to say, a vacant space formed by the way he had arranged his bedroom floor surfaces. What to do with this space would probably puzzle him. It was too small for even the smallest of bed-closets —and some builders have a most vivid imagination in the way of conceiving the smallest possible space in which a bed, so called, can be placed—and it would not even do if called a bath-room. What name, therefore, could be better given to this unmanageable space than that of "larder and store-closet"? And so it was called not a thought, apparently, being given to the fact that, so placed, it was for the workers down stairs practically useless. And so, in fact, it proved to be; for rather than keep "running up and downstairs" for everything they wished to take out of or put into this store-closet and larder, so called, they preferred to put up with all the inconveniences they possessed below. When we find, as we have often found, that the little crib of a place yclept in the language of the plan a "store-closet" or a "larder" is put in the most inconvenient, and for a larder the most unhealthy place, we generally conclude that it has got there by some such chance of planning as we have alluded to above. The planner finding that the laying out his floor space into what he believed to be the only apartments worthy of consideration, such as entertaining rooms, kitchen, and the like, had left a space which was too small to be made anything else of, and therefore could scarcely do otherwise than dub it a store-closet or a larder, seeing that *on* the plan—and paper—some name was necessary to be stated. Whether it could be properly and profitably used as such was not his concern. Had he not given a store-room? was not a larder provided—at least, some crib so named? What else could even the most exigeant of housekeepers require?

Good Planning involves Attention to All Parts of the House.

Good planning, then, to be at all worthy of the designation, involves the necessity to consider carefully *every part of the accommodation* of a house. It must not merely comprise those apartments in which the inhabitants live, but it must take heedful note of all those minor apartments or places which are essential in order that living shall be comfortable. Further, that this comfort shall be secured so that those who attend to it shall not be called upon to do unnecessary work and therefore undergo unnecessary fatigue. Humanity, indeed, demands the latter point to be carefully considered, and we feel assured that many a good hearted planner of a house would be shocked to be told that he was the cause of physically torturing the poor servants of a house he had built. And yet a very *little consideration will show that a poor servant will have all the physical torture of great—it is sometimes* intolerable—fatigue, incurred by frequent running up and down a flight of steps or along a passage of great length, both of which, and all other inconveniences of a like kind, could have been avoided had the house planner given to his design some careful thinking out.

Good Planning involves Considerations other than those yet named, as Points connected with Windows and Fireplaces.

But the requirements of good planning of houses are not all met when the rooms and the working conveniences are provided not only in exact number, but in proper arrangement. The planner has to consider, and should consider, such points as the way in which those places and apartments are fitted up with doors, windows, etc., etc. The convenience and comfort of a room depend very much indeed upon the way in which its component parts are related to one another. The position of the doors, the windows, and the fireplace, should therefore be considered most carefully. So important are the consequences arising from neglect of or inattention to this, that we should strongly counsel the young architect or builder to draw each room to a large scale, and carefully mark out the position of doors and windows and fireplace in relation to each other, and how this position affects the placing of the furniture. How important this work is may be gathered from the fact, which some may have a difficulty to believe as such, that some rooms are so arranged in the above respects that furniture *cannot* be properly placed at all in them. In a bedroom, for example, the bed cannot possibly be placed to avoid its being dangerously near the fire. Or this can only be avoided by its being placed across a window, which practically is equivalent to putting the window out of use, so far as its being opened and shut for ventilation and health purposes are concerned. In dining-rooms, again, the free wall spaces are very frequently so few and so short, that it is an absolute impossibility to place a longish piece of furniture, such as a sofa or a sideboard, without blocking up a window, so that it cannot be approached for any useful or necessary purpose. The writer of this paper has elsewhere in one of the professional journals gone somewhat fully into this department of house planning, and he may be permitted to give here a *resumé* or epitome of the leading points of his remarks.

Placing of Doors of Bedrooms.

It is certain that much of the comfort, assuredly much of the convenience, of a bedroom depends upon the way in which the door is placed, or doors are placed, with relation to the fireplace and the window or windows. Some are so carelessly planned in this respect – if the term "planned," indeed, can be here applied —that it is almost impossible to place the furniture in the way in which it ought to be placed. Not seldom are the bedrooms, from this cause, almost useless. With some, all that seems necessary is that the room should have a door; but whether it exercises any influence upon the convenience of the room as a place in which to sleep and move about in, does not seem to have been thought of. A very common mistake is to place the door in the centre of the wall next the lobby or landing place. This position almost invariably cuts up the furniture—that is, the free wall--space so much that it is not easy to place the articles or pieces properly, and in the case of small bedrooms is almost an impossibility. Thus, take for example a case in which the fireplace is to the right of the window, and the door in the centre of the wall leading from the lobby, and opposite the fireplace. Taking the space occupied by the bed, it will be seen that there is only one position in which it can be placed; and even this is an unfortunate one, as it throws the foot of the bed too near the fireplace. It cannot be placed in either of the corners, for the width of the wall surfaces at those points is so narrow that the sides of the bed come past the door architraves. The difficulty is still greater where the room has to contain a wardrobe, and where its area is comparatively small, for the corner wall spaces cannot take it in, and it cannot be placed up against the window. And if, to make room for the wardrobe in the corner nearest the door, the bed is placed nearer the fireplace, the inconvenience in this way is made all the greater. Or if the corner near the fireplace and farthest from the door and window is taken, the bed comes too near the door. All the difficulties named – and they are not fanciful ones, having been met with by no means seldom in practice—could have been avoided by simply putting the door in either one or other of the corners of the room. This gives great facilities for the disposition of the furniture. For there is now room for the bed head to be placed opposite the fireplace and against the partition wall separating the room from the lobby in which the door is placed. And this gives a good free space between the fireplace and the foot of the bed. Room can also be had for the wardrobe, which is placed to the left of the bed—that is, in the centre of the wall opposite the window.

Sketching out of Positions of Doors, etc., in the Plans of Bedrooms in Relation to the Positions of their Furniture.

The young reader should pencil a sketch showing the arrangement indicated above, and trace out all the possible arrangements of the fireplace, window and door in relation to the arrangement of the furniture. He will, in doing this, find that points are involved other than those named in last paragraph, which materially affect the comfort of those occupying the room.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER IV.

AT the conclusion of the previous chapter we stated that few vegetable dyes are now in general use, owing to the superiority of artificially-made dyes. Still, however, several of those natural products hold their ground in spite of many manufactured rivals, and are no less valued now than they were before the advent of the "anilines." These are indigo, logwood, bark, berries, and a few others, in addition to peachwood, sumac, etc., employed in dyeing on printed mordants. The use of indigo, both in printing and dyeing, being treated in a subsequent portion of our work, we pass on to the subject of logwood.

Logwood. This dye-wood is one of the most important of vegetable colouring matters. It is largely used, both in the colour shop as an extract, and in the dye-house as "rasped" wood. The only colours for which it is employed are black and lilac or purple. With iron and chromium salts it yields a splendid black, which is fast against soap and light. For printing, logwood liquor is mixed with mordant and thickening and printed, and is developed by ageing in the air or by steaming. In order to obtain a better black, bark liquor is mixed in the colour. A good example consists of about 12 gallons logwood liquor at 14° Tw., 4 gallons bark liquor at 12° Tw., 5 gallons acetic acid at 4° Tw., 30 lb. starch, 6 lb. dark British gum, 3 lb. chlorate of potash, 2 gallons of acetate of chrome at 38° Tw., and ½ gallon chrome alum solution at 20° Tw. All these ingredients are boiled together, except the chrome which is added after cooling. Of course there are a great number of other "standards" of logwood black made from the above by varying the proportions of starch and water. Also some blacks are made with more bark than the above. The object of using chlorate of potash is to aid the oxidation or development of the black.

Bark.—This is used chiefly in combination with logwood, as above stated, to produce a black. It also yields a yellow with alumina and with tin. It is used where a pure shade of yellow is not required, as it gives an inferior shade to berries. A good example of bark yellow is made from 1 gallon of bark liquor at 12° Tw., 4 oz. alum, 1 lb. starch; these ingredients are boiled till the starch thickens, when it is strained and is ready for use. It is largely used for obtaining *olive* dyes or colours—being combined with aniline green and logwood black, etc.

Persian Berries.—This product is largely used both in the colour shop and dyehouse. The berries are boiled with water, under pressure in an extractor, and the liquor obtained used in dyeing, and also in the colour shop; but the largest quantity of it is consumed in the colour shop in the form of berry extract. This is used for yellows, of which it gives a beautiful bright shade; it is largely used in general colour-mixing, especially in giving a yellow shade to aniline green, and in mixing olives. Alumina gives with berries a very pure canary yellow, whilst tin yields a pure yellow of an orange shade. An average berry yellow colour is made by boiling 1 gallon of the extract at 24° Tw., with 12 oz. of starch, and after cooling, mixing 1 lb. citrate of tin pulp. Citric acid is sometimes added; some colourists also use acetic acid in this colour.

The above three vegetable colouring matters are the principal ones now in use in the colour shop at the present day. There are, indeed, a great many other natural colouring vegetable matters which give beautiful shades, but these have been replaced or discarded in favour of cheaper and faster dyes. Thus weld and several other natural dye-wares are now seldom used except for "sightening," *i.e.* for mixing with some nearly colourless printing compositions, in order to let the printer see the impression distinctly. For descriptions of many other vegetable dyes which, though now seldom used in printing, are employed in cotton and woollen dyeing, the reader is referred to the chapter on "The Chemistry of Colouring Matters."

5. *Animal Dye — Cochineal.*—This is the only natural dye of animal origin now used in the colour shop, and that to a very limited extent only. An account of cochineal will be found in "The Chemistry of Colouring Matters."

Methods of Printing or Laying Down the Colours on the Surface of the Calico or Cotton Cloth. The Block Method.

The reader, having studied the foregoing chapter, should now be prepared to follow us while we explain the points connected with the actual use of the colours thus prepared in imparting to calico patterns of different kinds in infinite variety of form and colour; in other words, the operation of printing the calico. (See the papers entitled "Form and Colour in Industrial Decoration.")

There are two kinds of printing—block and machine or cylinder printing.

(1) *Block Printing.*—Block printing is the laying down of the design or portion thereof—whether in one or more colours—upon the cloth from a block of wood, upon which is cut the desired pattern in relief: the raised parts being coated with the thickened colour, the block is pressed down upon the cloth, so conveying the pattern to the cloth. Block printing is generally executed by hand; but in some cases a simple mechanical arrangement partially replaces hand labour. The block is usually, but not invariably, composed of

wood. It is generally made as follows:—The bottom or face on which the pattern or portion of a pattern is to be cut is of the best sycamore, with the grain running lengthways of the block; above this is glued and pegged a piece of common deal with the grain across the block; on the top of this again is another piece of deal, with the grain running lengthways. This is also both glued and pegged; and after the glue has been dried in the press, it is ready for further treatment. The pattern or portion of a pattern is now traced on or transferred to the face of the block, and is then carefully cut out by the block-cutter. This cutting requires great care and skill for its execution; and where very fine lines occur in the design, the upper block is copper instead of wood. Some designs require only one block; others require more—sometimes as many as thirty or forty—each block corresponding to a certain portion of the design or pattern, each printing a separate colour.

The block printer requires to be very careful, in blocking with a number of blocks, that each block is accurately joined with or fitted into the other, so as to form the whole continuous design. This, in the analogous process of printing in colour with the ordinary printing or the lithographic machine, is technically called "registering."

The colour is put on the block by dipping it on a sieve made of stout oilcloth, floated on gum of sufficient thickness contained in a box slightly larger than the sieve; the colour being evenly "teared" or spread on the sieve by a boy by means of a small flat brush. Great importance is attached to tearing and also to dipping the block in the colour, that it be laid perfectly flat upon the sieve, and not on one end or side more than another. After dipping, the block is laid on the cloth and gently pressed with the hand sufficiently hard to get a good clear impression; and so block after block is laid on the cloth until the pattern is complete. There is another kind of blocking called "grounding," or "tobying," which is employed in combination with machine printing. In this case the blocks are employed only to fill in any colour which would not stand the processes which it would require to undergo if it were printed by the cylinder machine; also "tobying" is used in cases where the colours blocked in would injure the other colours if done by the printing machine, and so have to be done separately.

On the Continent, where labour is much cheaper than in Great Britain, block-printing is carried on much more extensively than here. Continental calico printers produce much more elaborate prints than we do, owing to the adoption of a combination of machine and block printing.

By blocking a greater number of colours and shades may be obtained than is possible by machine printing, and doubtless in some instances finer shades may be obtained by the former process than by the latter.

The Methods of Printing or Laying Down the Colours on the Surface of the Calico—(2nd) Cylinder or Machine Printing.

This method of laying down a pattern upon calico in one or more colours has a vastly wider application than that we have just been describing. And it as far surpasses that latter method, in nearly every particular, as the modern printing-press surpasses the ancient method of hand printing by means of separate wooden blocks. The modern printing-machine is a highly complicated invention, which works with a degree of precision surpassed by very few other machines of equal complexity.

The main principles of the printing-machine may be readily understood by an examination of fig. 8.

In this figure *a* is the cylindrical printing surface or bowl, *b* is the copper engraved roller, *d d* is the colour-box, containing the furnisher roller *c*, half immersed in the colour, *e* is the colour doctor, weighted by *f*. The cloth to be printed enters the machine at, and over the wooden roller at top left hand, in the direction of the arrow, where it passes along with the back grey; it passes round the cylinder in the direction of the arrows until, passing between the roller *b* and the bowl *a*, it receives the impression, and passes along with the grey out at the arrow at right hand at top, thence passing by itself to the drying apparatus. The copper roller revolves in the direction shown by the arrows, and by the great pressure with which it bears upon the bowl *a*, revolves the latter, carrying with it the cloth. The furnisher-roller (which furnishes the engraved roller with colour) is also driven from the axis or mandril of the engraved roller. As the copper roller *b* receives its charge of colour from *c*, the colour from the unengraved parts of the roller is removed, or scraped off, by the doctor *e* before reaching the cloth. Hence, when passed the doctor, its *engraved* parts or design, or portion of design, being filled with thickened

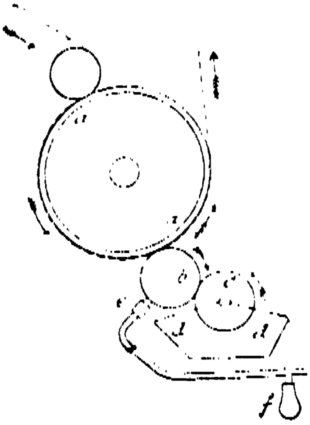


Fig. 8.

colour, the smooth or unengraved parts being perfectly clean; on coming in contact with the cloth, and being heavily rolled thereon, the coloured design upon its face, it holds, sunk slightly below its surface, an even layer of thickened colour of the requisite tint or shade, transferred to the cloth partly by being *forced* or pressed, and partly by being *sucked* into, the fibres by capillary attraction.

The Cylinder Printing Machine—Description of the Main Parts.

1. *The printing surface, cylinder, or "bowl,"* as it is variously termed, is a large cast-iron cylinder in the centre of the machine, supported on each side by centres or bearings on the side frame. These revolve in a movable brass step in the ends of the machine or framework, connected with powerful screws, workable by hand, enabling the cylinder to be raised or lowered as required, in order to permit of removing the copper rollers more conveniently, and also to counteract the pressure of the rollers upon it. This is driven or dragged round by the copper printing rollers revolving and pressing against it. It is wrapped with finely-woven thick cloth, called "lapping," in order to get a hard, though slightly elastic surface.

2. *The Framework* consists of two similar castings, which vary in size and shape according to the size of machine and number of colours. The two sides are from three to four feet distant from each other, according to the breadth of cloth required to print. The two sides, or ends, are connected together by cross-bars and bolts. The framework is constructed to support in perfect steadiness the heavy central cylinder and all the printing parts of the machine. It is firmly secured to a massive foundation of stonework. Arms project from it, bearing a mandril, colour-box, etc., for each colour the machine prints.

3. *The Crown Wheel.*—This is a large toothed wheel, made to revolve by the motive power in the same centre as the pressure cylinder, but *outside* the framework. From this wheel is driven the "box-wheels," which are fitted on to the "mandrils," and so make the copper roller revolve, the pressure of which against the printing cylinder makes the latter revolve.

4 and 5 *The Engraved Roller and Mandril.*—The mandril. or axle of the engraved roller *a b c d*, fig. 9, may be made either of steel or wrought iron, the latter being that in general use. It consists of a round rod, with a slot about four inches in diameter, into which fits the "tab" of the copper roller, or projecting piece, about ½ inch broad and ¼ in. high, which thus holds it tight and prevents any slipping when in work. The mandril also is turned with necks to fit in the brass steps in the frame at each side. The steps are constructed with two screws, so that by the use of one the mandril and roller may be pushed across, or from one side to the other of the machine, as required. And by the other screw, which is a strong one, and which moves the colour-box, mandril, roller and doctors, the pressure of the roller on the printing cylinder may be decreased or increased as required. The mandril revolves in sliding pieces, carried in arms of the frame. The sliding pieces move by means of powerful screws, by which any desired degree of pressure of engraved roller upon the central cylinder can be obtained. This arrangement for adjusting the pressure of printing copper roller upon the cloth is of great importance, and one of the most important duties of the printer is the proper and accurate adjustment of this pressure. Also, it may be observed, it is important to regulate the pressure of roller upon cylinder at each end of roller equally—otherwise the printing upon one side or edge of cloth will differ from that on the other, or will be uneven. There is another arrangement for adjustment of roller, which is of the utmost importance, but which we have not yet mentioned. This is the screw confined in a shell in the toothed wheel, by which the mandril is driven off the crown wheel, by turning which the roller is slightly turned *on its axis*, so as to enable the printer to fit his colours properly. This is further referred to in the paragraph upon "pitching the rollers."

The engraved roller, *e f g h* (fig. 9), is revolved by the mandril or axle. The roller is a massive copper wide tube or cylinder, open at both ends, the walls being on an average about ¾ in. thick. On the inner wall, or interior of tube, runs a projecting ridge, or as it is generally called "tab," from end to end, which fits into the slot in the mandril, as before mentioned. For the engraving of this roller the reader is referred to the chapter devoted to that subject.

6 and 7. *The Colour-Box and Furnisher.* The colour-box is a wooden or copper receptacle to contain the colour-mixture used in printing. It is fitted underneath, and is rather larger than, the copper roller. In this box is a wooden roller, which revolves upon brass bearings on its sides or ends. This roller, or "furnisher," is driven off the mandril by a small brass cog-wheel, which works into a corresponding wheel on the end of the axle of the furnisher. The furnisher revolves, half immersed in the colour-mixture and half above it, in the same direction as that of the copper roller, against the copper roller, thus conveying the colour to roller by continually lifting it and slightly pressing it against the copper roller. The revolution of the furnisher is generally slightly quicker than that of the roller, its tooth-wheel being rather smaller than the cog-wheel of the mandril. Thus a kind of slight scraping, or rubbing the colour against surface of engraved roller, takes place.

THE MACHINE MAKER OR GENERAL MACHINIST.

SPECIAL EXAMPLES OF HIS WORK—ITS LEADING TECHNICAL PRINCIPLES AND DETAILS.

CHAPTER III.

We concluded the last chapter by stating that a mechanic might make a good machine, and yet be unable to explain the natural laws on which its operations were based; or that he might be ignorant of the fact that they in truth depended upon natural laws. But further, and this is readily enough admitted, the practical mechanic of the higher grades of the profession does in his work daily take advantage of certain rules and modes of calculation based upon formulæ which are due to the labours of scientific men or of theorists. And this in order that he may have all the advantages of a system which gives him the maximum of efficiency with the minimum expenditure of material. Still more, it is admitted -pretty widely known, indeed, even by those outside the mechanical world, or rather not connected in a business way with machine-making and engineering work that the machinist, the manufacturer, and the technical industrial worker, are now using machines of the most valuable practical character, which have owed their existence, so to put it, to, or been deduced from, purely theoretical investigations and calculations.

The Practical Machinist in his Work preceded that of the Theorist in Applying Science to the Details of Machine Making.

It is from all this, and in some directions more than this, that at least the popular notion has arisen to which we have above alluded,—that the work of modern machinists, in all the wide varieties of its practice, has owed its existence to the theories of the scientific man. But the young technical reader and machinist will perhaps be surprised to learn that the opposite, or almost the very opposite, of this is the true condition of matters; and that this may be said to be practically the correct statement of the case—namely, that modern machinery is based upon the work of the early machinists in their rude workshops, which was done patiently step by step, and that in the slowest and most painful of ways, not only without any help from theorists or scientific men of the period or of periods before, but mainly in utter ignorance of the fact that scientific men had even thought their work worthy to be made the subject of theoretical disquisition. Book after book—and some of them in their mere bulk were portentous and solemn-looking affairs—was published, treating on the laws of mechanics, and illustrating what were called "engines," possessed of wondrous mechanical—so-called—"powers," and yet of the very existence of such books, the great majority of the working mechanics of the period were ignorant. Nor is it anything but the mere formal statement of the truth, that from this ignorance they suffered no practical loss, and this for the best of all reasons—that, taking them all round, such books contained nothing or next to nothing of any practical workshop value to the working mechanic. If, however, they gave more than this, and what might have been, and in reality was, the germ of a useful machine, it was so wrapped up, so to say, in terms, and obscured by verbiage, that it was useless to the practical working mechanic and machinist. Even after the time when our early machinists had brought out mechanism which did the actual daily work in some branches of industry, the authors of such works as we have above alluded to thought it beneath their dignity to notice such machines. The *doing* of work of practical utility seemed to be the very last thing which those theorists thought about. But of what may be called the "romance of mechanism" their works abound in illustrations: diagrams of so-called mechanical combinations, intricate as fanciful; most abstruse and fearfully spun-out calculations and speculations to prove, for example, that enormous weights could be lifted by hairs, or straws as weak as hairs, but not a drawing indicating an arrangement, not even one showing a single part, of a mechanical construction which could be made to *do* work of any kind. There was no end to the disquisitions on, to use a tautological phrase, the wonderful powers of the "mechanical powers," but scarcely a line could the practical mechanic find to help him in his duty of making those powers do his work. For a long time, it may almost be said for many generations, this was the character or nature of what might be called the scientific treatment of mechanics; and, singular as it may appear to the young reader, mechanics became truly a science, and was so expounded by men of science, only after the men of practice, the actual working mechanics, with long years of patient labour, and by the expenditure of much true mechanical ingenuity, had brought out machines, and set them actually to do a wide range of work, that scientific men deemed it necessary to take up the subject of mechanics and mechanism, and treat it in such a way as to be really a practical help to the future and further progress of the practical mechanic. But as to how much the man of science was indebted to the man of practice, many do not know, and as it is important to know, we shall now trace, as fully as space will admit, the history of progress in this direction.

Some Points connected with the Applications of Theory to the Practice of Machine Making.

As we have above stated, the theorist at one time, and that at a period not so very remote from our own times, had almost complete possession of the field, and assuredly he indulged to the "top of his bent" in cultivating it in his own peculiar fashion; and that it was a fashion leading in no direct practical way to the progress of mechanism—or machinery, to use the modern term—may be learned any day by those who choose to wade through the somewhat shallow streams which spread out widely enough over the field of the mechanical literature of the period referred to. For long, indeed, the trade or calling of the machinist did not exist in anything like the sense we now attribute to the term. The very fact, to which we have alluded, that the appliances by which alone machines could be made did not exist, rendered any complete "trade" a practical impossibility. The work of the "mechanic" was of the simplest and rudest character. The very name, indeed, was used by all classes making up the higher ranks of society—the theorists or writers themselves included—in a way which indicated the esteem, or rather the lack of it, in which he and his work were held; the very term "base mechanic work" becoming stereotyped in our language, and used, moreover, by men professing to be scientific, who ought to have had some better and brighter conception of the true dignity of the calling, and how potent an influence its work possessed in promoting the welfare and ministering to the material necessities of the nation. But it was long before the machinist took the place he now occupies, and did the work he now does daily, in this high and useful direction. And yet, if theory had been of any great practical service, the mechanic of the early times we allude to had no end of its prelections at his service, if he had known of or cared to avail himself of them. Portly tomes, as we have hinted at, were published from time to time, filled to the full with most picturesque and apparently attractive drawings or designs of wonder-working machines, and with intricate diagrams and no less intricate expositions of movements or "mechanical combinations"—if at that time this phrase could be applicable—which proposed to do most wonderful "feats of force."

Assuredly, if the mechanic, not then or as yet raised to the dignity and the practical value of the calling of the *machinist*, had been led to the perusal of such works, he would have found enough in them to gratify his ambition as to what he might or could do if only he could work out the wonderful combinations which these works so lavishly and so generously offered to his notice. But somehow those did or would not serve any practical purpose. It mattered little for the mechanic to be told that by certain "mechanical contrivances" duly set forth by a complication of lines more or less elaborate, but always puzzling, and explained or expounded by a long array of mathematical statements and figures even more elaborate and vastly more puzzling, he could do most wonderful work—such as to realise the boast of Archimedes that if he could have but a fulcrum and a lever long enough, *he* with his tiny power could move the globe. Nor were marvels of a lesser kind awaiting, but still marvels all tending to show the wonderful capacities of so-called mechanical agents which seemed to have some inherent power in themselves. Thus one writer on mechanics, who, like all other writers before him, and like some in our own times, or pretty near them, ought to have known better, revelled in the region of the wonderful of mechanism, and its almost infinite powers, pointing out that by these "mechanical contrivances" it were "easie to have made one of Samson's hairs that was shaved off to have been of more strength than all of them when they were on." Assuredly it was "easie" to write about such wonders; but it never seemed to occur to any one of those who so readily offered such prelections that they were utterly vain as regarded any practical utility in the every-day work of life, and that from all their complicated diagrams and no less complicated explanations, the practical machinist—so far as he in those early times existed—would gain nothing which could be of possible service to him. One important truth such writers utterly ignored—not that many of them were, if indeed any one of them could be, ignorant of it—and that was the element of "time." Some of them, indeed, saw the value of this; they could enforce the doctrine, in truth, which every schoolboy in mechanics knows, or at least can repeat by rote as if he did know—that what is gained in power is lost in time. But so purely from a theoretical point of view was everything in the times we write of considered, that it never entered into their speculations that it must of necessity affect in the closest manner the actual work of the machinist who had *work* to do, and in which *time* was an all-essential point. One can scarcely now, with the light of our experience, comprehend how writer after writer could have a thorough understanding of the vital truth which such a statement as this from the pen of one of them contained: "The immense force of the mechanical powers would be infinite and altogether stupendous if it were not that the greater the force is, the more slow their operations are," —and yet so thoroughly and practically fail to perceive that all their marvels of "mechanical contrivances," the mighty work done by imaginary levers, and the wondrous strength of supposititious hairs, were of no avail to the machinist of the day, with whom time was an element which he could not, if he would, ignore.

THE STONE MASON AS A TECHNICAL WORKER.

THE PRINCIPLES AND PRACTICE OF, AND THE MATERIALS HE EMPLOYS IN, HIS WORK.

CHAPTER III.

Principle and Illustration of "Bond" between, or "Bonding" on Stone Walling.

IN addition, then, to the full binding power of a mortar or lime "cement" (see this term in the "Cyclopædic Dictionary of Technical and Trade Terms") the science of masonry has devised a method by which, in carrying out the art of setting the stones it uses, a mechanical arrangement is given which binds the individual stones together, forming a coherent and largely solid mass. This arrangement is technically termed "bond," and stones set in a wall or structure properly are said to be "well and truly bonded." What the principle of this "bond" is we shall endeavour to illustrate and explain.

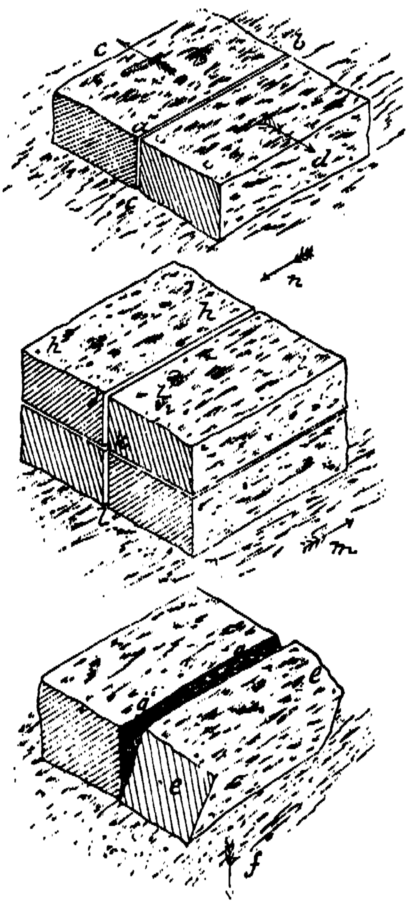


Fig. 20.

Let us suppose that two stones lying on a flat surface, as the ground (as *a* and *b*, fig. 20), are placed together, so that the joint formed by the juxtaposition and contact of the two is formed at *a b*. If they be simply placed in contact, should any force act in the direction of the arrow *c*, so as to tend to cause the stone *c* to slide away from the stone *d*, the two would clearly be separated, and the joint *a b* would open up or widen, and contact between the two would, if the movement went far enough, be obviously destroyed. The tendency to separate the two stones would be all the greater if another force acting in the direction opposite to *c* operated in the line indicated by the arrow *d*. The same result of separation of the two stones would take place if the one stone, as *e e* in the lowest diagram, rested upon soft or treacherous ground or soil: it might sink down towards the side *f*, and in the direction of the arrow at that point. The result, so far as the integrity of the "joint" *g g* is concerned, is shown in the illustration. As between the two stones originally placed at *c d*, joining at *a b*, the keeping of the two in contact might be in some degree ensured by placing two stones above them, as shown at *h i* in central diagram in fig. 20. But this would only be by increasing the cementing surfaces if mortar, or the frictional surfaces if placed without mortar or cement. Any pressure acting either as at *c d* or *m*, in the two first sketches of the figure, would still have the tendency to separate the joint between them: for the joint represented by the line *j k* in central diagram runs in line with that, *k l*, of the two lower stones.

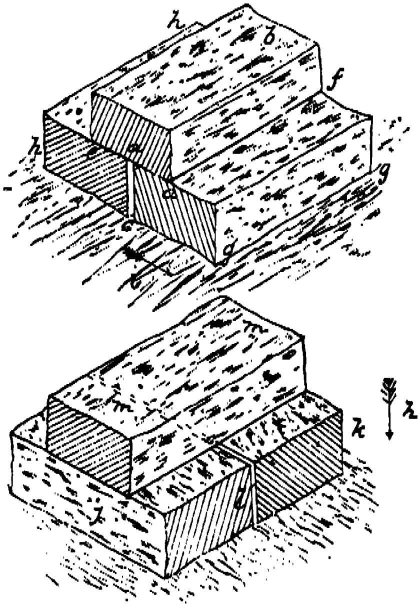


Fig. 21.

Analysis of the Principle of Bonding of Stones.

The pupil will have a simple exercise, yet one which will serve to give him some useful hints, if he works out mentally the different results of pressures exerted upon the stone in the illustration in fig. 20: those pressures being exerted by the arrows as *c*, *d*, *f*, and additional pressures acting in the directions as at *m* and *n*. If he does so, he will not be long probably in perceiving that the condition of the joint *a b* would be materially altered if, in place of superimposing upon it two stones, as at *h h* and *i i*, one stone, as *a b*, fig. 21, were placed as there shown. Let the pupil study the position we have now arrived at. He will see that the solid part *a* of the stone *a b* lying on the upper surface or part of the surfaces of the two stones under, is centrally over the joint *a c* of those two stones. Let him suppose that by a bed or stratum of mortar the "bottom bed" of *a b* is connected closely and firmly to part of the upper beds of the two stones *g g*, *h h*. Suppose now that a pressure acting in the direction of the arrow *i* has a tendency to move the stone *g g* towards the right hand, while the stone *h* remains firmly fixed in or on the soil, and has no pressure corresponding to that at *i* acting upon it. To resist this pressure there is now not merely the strength of the mortar or cement, as in the case before considered in connection with fig. 20, but there is also, in addition to this, the resistance of the cement or mortar to be overcome, which is spread over the half of the bed of the block *a b* resting on the block *h*. In this case we do not here take into account such resistance as would be offered by the mortar joint on the half of *a b* resting upon the block *g g*, which is under the pressure. But this resistance would be just so much the more in favour of the two stones *g g*, *h h*, being separated by the rupture of the joint at *a c*—that is, the joint would be all the stronger by the mortar between the edges of the two blocks.

Take again the case of the two blocks *j*, *k*, jointed at *l*, and the joint partly covered, not wholly so, as in the case of the block *a b* in the other sketch in this figure. Suppose a pressure to be exerted on the brick *k* in the direction of the arrow *n*, and at the corner nearest it, and that the soil under *k* was soft and yielding. Here the result, as shown at *g g* in fig. 20, would not be so likely to happen, for not only, as there, is the cementing resistance of the mortar of the joint the only force to resist rupture; but in fig. 21, in addition to this at the joint *l*, is the resisting power of the mortar joint under the bed of the whole of the under side of the block *m m*. So that before the block *k* would yield to the pressure put upon it, as at arrow *n*, and would be forced into the yielding soil, the block *j*, which we suppose to be on firm ground, would be raised like a lever, the fulcrum of which would be the corner nearest *n* of the block *l*. And this resistance of the block *j* to the pressure exercised at *n* would only cease when the cementing power of the bed of the block *m* was overcome by the rupture of the joint of its bed. In those two cases represented in fig. 21, we have two resisting powers to any pressure tending to rupture the joint, as *a c*, or *l*, of any two blocks cemented together by mortar: first, the cemented joint, *a c* or *l*, itself; and second, that afforded

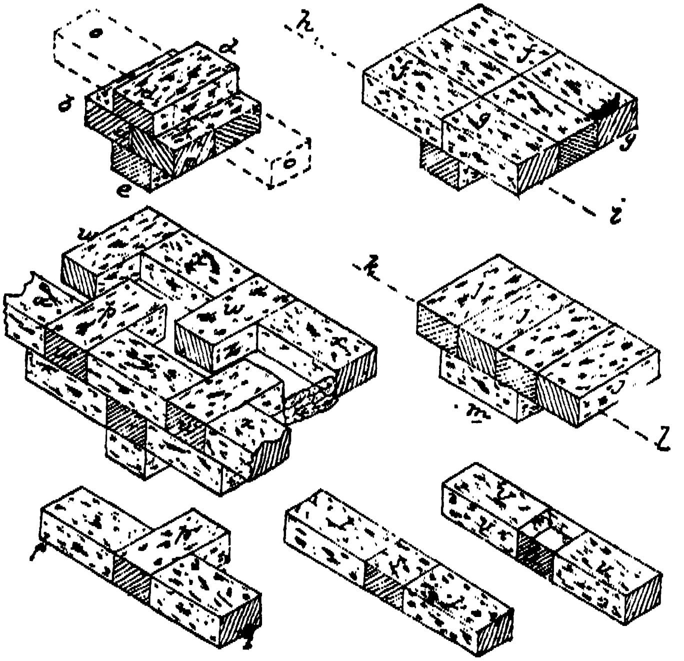


Fig. 22.

by the bed joint of blocks *a b* and *m* resting on and cemented to the top beds, or part of them, of the two blocks *h g* and *j k*.

"Breaking Joint" an Essential Feature of Bond.

It is obvious that by thoughtful arrangement of the blocks of stone the joints of any course in the construction of a wall may be so arranged that they may be covered by the solid parts of the blocks of the courses above and below them. Thus the joint *a* of the two blocks *b* and *c*, fig. 22, is covered by the solid parts of the blocks *d d* and *c*. This is technically called "breaking joint," and the principle is adopted in more than one branch of the constructive arts, mechanical as well as building. These arrangements of blocks to secure this sound principle in construction technically constitute "bond," or in other words that by which the individual blocks are bound or tied together. If the blocks were all of the same length, and placed invariably in the same relation to each other as the blocks *f f*, *g g*, either parallel in the sense of their length to the line *h i* of face of wall, or at right angles to it, as *j j* to the line *k l*, while "breaking joint" could still be carried out by proper arrangement of the blocks as shown at *m* and below *f* and *g*, this mode of disposition or "placement," to use the technical expression, would not give the greatest or strongest form of "bond." In practice, if the blocks are of the same dimensions—as in the case of bricks (see the series of papers on "The Bricklayer, his Material and Technical Work")—they are disposed so that part are placed in the wall parallel to the line of its face, as at *f*, and part at right angles to it, as at *j j*, fig. 22; so that, although of similar length considered in relation to the breadth or thickness of the wall, they may be looked upon, to use a familiar phrase, as being "longs and shorts."

"Longs" and "Shorts," "Headers" or "Stretchers" in Bonding of Stones.

Thus the block *d d* in fig. 22 is a "long," considered in relation to the breadth or thickness of the wall; and the block *o o* a "short," as it only reaches across a part of the thickness or breadth of the wall. When blocks are thus placed, as at *o o*, *f f*, or *g g*, fig. 22, to run along the length of the wall, they are technically called "stretchers." If they are placed so as to run across the thickness or breadth of the wall, or at right angles to its line of length, as at *d d* or *j j*, they are termed "headers." A wall, therefore, is built up with a series of "headers" and "stretchers," so disposed in relation to each other that they "break joint" in the way already explained and illustrated. The way in which they are thus disposed varies according to circumstances, and constitutes what is a particular bond, which goes by its special name—as, for example, in brickwork (see "The Bricklayer") the kinds of bond termed "Flemish" and "Old English." In stonework the blocks are not always of the same length, but the length of the shortest is, or should always be, greater than the breadth of the longest—as the block in the centre of the lowest diagram to the left of fig. 22, being larger than the breadth of the blocks on each side of it, projects beyond those, as shown. This projection is obviously necessary to secure "bond" with other blocks; and this would not be obtained if the short blocks were equal in length to the breadth of the long blocks, as the block *s* to the blocks on each side of it in centre of lowest diagrams in fig. 22. The case would be worse if the short blocks were less in length, as at *u*, than the breadth of the long block *v v*. But when the stone blocks are of unequal length, they are still disposed in a wall or structure on the same principle of "longs and shorts" alternately.

System of Interlocking of Stones of Different Lengths secured by "Bond"—"Throughs" or "Through Stones."

The complete way in which the individual blocks composing or making up the solidity of a wall are interlocked, so to say, with each other, or bound or "bonded" together, is partially illustrated in fig. 22, in the sketches at top of diagram. That to the left may be taken as part of a solid wall of blocks, either "ashlar" or rough hammer-dressed coursed rubble work. The block *d d*, although a "header," is termed specially in the technical language of masonry a "through," inasmuch as it goes completely through the thickness or breadth of the wall; its two ends showing at each side of it, interior and exterior. The blocks *o o* and *b c* are "stretchers." The top sketch in fig. 22, to the right, may be taken as an illustration of a composite wall, or made up of solid blocks, or of "ashlar" or of "coursed rubble" work; those blocks being placed or disposed so as to form the outside faces of the wall, inner and outer, while the central part of it is filled up with small stones or "rough or random rubble" work. But the blocks, although of equal length, are disposed as "longs or shorts," or as "headers" and "stretchers," as in the lower diagram to the left. In fig. 23 *a a* is a "through."

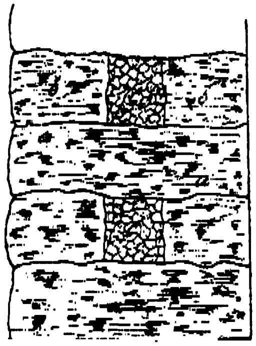


Fig. 23.

THE YOUNG ARCHITECT OR ENGINEER.

HIS STUDIES—OFFICE DUTIES—AND PRACTICAL WORK IN THE PREPARATION OF WORKING DRAWINGS, OF SPECIFICATIONS, AND CONTRACTS FOR WORK.

CHAPTER IV.

The Finished Roof Plan of the Building

is the last of the series of the drawings of which the block plan is the first. It represents the appearance of the roof when complete, with its covering of tiles, slates, lead, or whatever other materials may be used; also all gutters, drips, cesspools, skylights, chimneys, hips and valley flashings, ridge and hip tiles. When the roof is perfectly symmetrical, one half may be drawn as a finished roof plan, and the other half as the plan of the roof timbers. The eaves or trough gutters for carrying off the rainfall form an important portion of the plan; the inclination must be indicated by arrows, and the position of the down-spouts shown. The gutters of important buildings are generally covered with "snow-boards," formed of timber, to prevent them from being blocked with snow, which frequently might otherwise be blown in from the more exposed portions of the roof.

Slates and tiles of different colours are occasionally arranged in patterns on the roofs of schools, churches, and domestic buildings, to break the monotony of a large expanse of roof; the design should be drawn on the finished roof plan, and the different colours indicated by tints. A necessary feature of every roof --more especially of detached buildings—but one which is frequently omitted, is the lightning conductor, and the copper wires connecting it with every portion of the roof formed of metal, as lead flashings, lead and iron gutters, finials, etc. For a building of moderate size, one conductor, fixed at the highest point, will suffice. The wires connecting it with every metallic material on the roof must be indicated by red or blue lines on the finished roof plan—which, in addition to what has been mentioned above, shows the view, looking down, of the upper surface of the highest masonry and brickwork, cornices, parapets, gables, finials, etc. It is usual to show them on the plan, protected by lead, asphalte, or other suitable material; occasionally only the joints are protected.

Plans of Ceilings of Large Rooms, Staircases and Corridors.

Plans are occasionally included among the contract drawings of the ceilings of large rooms, staircase halls, and corridors; when they are of an ornamental and elaborate design they should be invariably drawn from centre lines, and are generally described as plans "looking up." The contract drawings were subdivided above into plans, elevations, and sections, the general character and mode of preparation of the plans having been described; a few words on the elevations and sections will complete this portion of the subject.

The Elevations

are the drawings which illustrate the design and style of the exterior of a building, and indicate the materials of which it is constructed. The number of elevations will necessarily depend on the peculiarities of the site and of the plans; every portion of the exterior not abutting on another building will require a separate elevation, and when large courtyards are included in the plans, separate elevations, facing them, must also be prepared. Those of smaller areas are generally included in the sections.

Before commencing an elevation, the extreme length, the slope of the ground, the heights of the floors and of the window-sills above them, must be ascertained and indicated on the drawing, as well as the centre lines of the doorways, projections, recesses, bays, and all other features which can be obtained from the plans; the young architect will then be able, after deciding on the style to be adopted, to commence his design.

Style of the Elevations.

No instructions can be given for this portion of the work; it requires a thorough knowledge of the style selected, and an acquaintance with buildings or with reliable illustrations of buildings that have been already erected in the same style by architects of undoubted experience and ability. True knowledge of style can only be obtained by the preparation, on the part of the student, of measured drawings and sketches. (The possibility of a design being produced in an entirely new style is so very remote that it need not be discussed here.)

Lastly, concentration of thought, and, above all, "brains," are necessary to produce a design which will look equally well on paper and in reality. It need scarcely be remarked that probably the majority of designs prepared appear more satisfactory as a drawing than they do after being carried out in brick and stone. This is owing to the fictitious effect obtained by colouring, shading, and other artifices adopted to conceal weakness of design; it is only in the work of the most experienced architects that the appearance of the building is more pleasing than that of the drawing.

The Importance of Selecting the Material of which a House is to be Built, in Keeping with its Style of Design.

The judicious selection of the materials to be used is of the greatest importance in the production of a satisfactory design, as it need scarcely be pointed out how completely they will affect the proportion and outline of all architectural features. The exterior of a building erected without, or with only a very sparing use of stone, must be treated in a very different manner from that of a building in which stone is wholly or largely used. We need only direct the attention of the reader to any one of the many buildings erected in one of the classic styles, examples of which are to be found in every moderately large *town, and to examine for a moment the columns, entablature and pediment, the windows and doors, with their miniature architraves and pediments; it will be at once evident that stone is the only material suited for the exterior of such buildings. The comparison of a church erected of stone with one erected of brick will* also forcibly show the influence of material on design. It may be stated here that the use of cement or plaster in imitation of stonework, so frequently seen on the Continent, and occasionally in this country, in buildings erected in the Italian and Classic styles, is not "architecture," and would not be tolerated by any conscientious architect. The beginner is warned never to attempt to obtain architectural effect by the use of one material in imitation of another. The general rule to be followed in the selection of suitable materials for the exterior of a building is to use those found in the locality in which the building is to be erected. From the time of the Normans until the introduction of greater facilities of transport by means of canals and railways, this rule has been closely adhered to, except in the cases of large and important buildings, as cathedrals, churches, and monasteries, for which the materials have been frequently obtained from a distance. The "half-timbered" houses of South Lancashire, Cheshire, Shropshire, and other counties, the "halls"—a name applied to even very small farmhouses—are only found in districts in which stone cannot be quarried or is unsuited for building purposes. The old towns of Manchester, Stockport, Chester, Shrewsbury, and many others, contained principally half-timbered houses, many of which have only been taken down to make way for buildings more suited to the wants of the age within the last century. On the other hand, the houses throughout the hilly portions of Lancashire and Yorkshire were erected of stone. This change of material in buildings of the same age and erected for the same purpose can be well seen in the districts lying on the north and south side of Manchester: in the former a half-timbered building is the exception, and in the latter very few stone buildings intended for domestic purposes were formerly erected. Buildings dating from the two centuries preceding the introduction of railways were generally erected of brickwork in districts in which stone was not readily obtainable.

The drawings are generally described as front, back, and side elevations; they may be completed in different ways: if entirely faced with one description of stone, they may be simply inked in and left without colour; but if, as is generally the case, several varieties of stone are used, or a combination of stone and bricks, they must be coloured, so that each material may be distinctly shown. It is usual to make the tints correspond as nearly as possible with the materials they represent. Contract drawings should not be shaded. *An attempt to obtain variety or contrast of colour by the use of various materials in imitation of buildings erected in the south of Europe should not be attempted by the architect. The climate and smoke of all our large towns soon destroy any architectural effect depending on colour, and tone the whole elevation down to a uniform* grey tint of soot and dust. When the materials forming the "facework" of an elevation are different from those forming the body of the wall or building, they must be carefully "tied in" by "headers." When stock bricks are used for facework, all the bricks forming "headers" must be whole.

Sections of Buildings required

are drawings of the greatest importance. They show the interior and general construction of a building, the heights of the rooms, the various levels of the floors, and the staircases by which they are reached. If is always somewhat difficult for the architectural student, or the general reader who has not had many opportunities of examining architectural drawings, to thoroughly understand a section. If the reader stood in a street facing a building, and imagined the front wall removed, he would see a section. The ends of the internal cross walls would be visible, the space between the ceilings of one story and the floor of the rooms above, the construction of the roof, and the general interior of all the rooms abutting on the street. Or if he stood facing the west end of a church, and imagined the gable wall removed, he would see the whole of the interior, including, in addition to the exposed ends of the walls, the floor and roof construction, the elevation of the chancel arch, the reredos, altar, east window, pulpit, reading-desk, font, and seats. The number of sections required will vary, of course, with the features and size of the building. If only two are required, they are called longitudinal and transverse sections. The former is generally taken through the building in the direction of its greatest length, by preference along the line of the roof ridge, and the latter at right angles to it. When three or more sections are included in a set of drawings they are described as "Section on Line A B," "Section on Line C D," and so on, the line on which the section is drawn being indicated on the plans by means of a strong red line with the letters "A B," "C D," at either end, so placed as to indicate the direction in which an individual would face if he stood in the building when erected, in order to see the view depicted on the section. The portions of a building which should always be shown on the sections are the interiors of important rooms, staircases, roofs, showing pitch and construction of principals, the floors, every variation of level, and all special and important features. Sections should be drawn through all the exterior walls, showing the relative quantities of masonry, brickwork, and other materials, the foundations, footings, plinths, string-courses, windows, sills and heads, cornices, parapets, gutters, and dormers. Small portions of elevations are occasionally, as stated above, included on the sections when they are taken through areas or small courts, or in front of slightly projecting bays or wings.

Important Uses of Sections, alike to the Designer and Constructor.

The preparation of the sections draws the attention of the architect to many points of construction which might otherwise not receive due attention, or be overlooked. "Headway" must be provided under every landing, the relative heights of large and small rooms adjusted so as to economise space, principals and other roof construction must be worked out, as well as the construction of the floors. The systems of ventilation and warming proposed to be adopted in the building for which the drawings are being prepared, can be shown on the sections; all flues, chimney-shafts, boilers and boiler flues, shafting, belting, engines, machinery, and hoists. Heights and levels of each floor must be carefully figured; it is usual to do so from floor to floor, not from floor to ceiling. A string of dimensions should be given from the foundation to the roof ridge, with a datum line fixed from a point on or near the site, which must remain undisturbed during the erection of the building.

Great Number of Section Drawings required in many Buildings.

The sections cannot be commenced until the plans have been tolerably worked out. They should be drawn in outline before the elevations are commenced. Some idea of the number of sections required to illustrate the interior of a building may be obtained by a careful consideration of the following examples. Let the reader place prominently before his mind a church consisting of a nave with a tower at the west end, north and south aisles, porches and transepts, a chancel with a vestry on the north side, with cellar under for heating apparatus, and an organ chamber on the south side. The following sections would be required to fully illustrate the interior of such a building: A section on a line commencing at the centre of the east end of the chancel, and passing along the line of the roof-ridge to the centre of the west wall of the tower, with letters A B so placed at each end of the section line that any one attempting to read them must have the chancel on his left-hand side. On this drawing would appear a section through the east window, reredos and altar, an elevation of the south interior of the chancel, with the arched openings into the organ chamber, a section of the chancel arch, internal elevation of the gable wall of the south transept, and the elevation of the south side of the nave, with the arcade and clerestory, a complete section of the tower, and sections of the floors and roofs. A second section would be required at right angles to the first, across the nave and aisle, and through the porches looking west; a third and fourth extending from the centre of the gable end of the north transept to the centre of the gable end of the south transept, one looking east, the other west; a fifth section at right angles to the first across the chancel, vestry, and organ chamber; a sixth from the centre of the east end of the chancel along the line of the roof-ridge as far as the chancel arch, looking north; and lastly, a seventh section across one of the transepts and porches, at right angles to the third and fourth. When the whole of these sections have been drawn, it will be found that every portion of the interior of the church has been illustrated—presuming, of course, that the north and south sides of the nave are similar in design. An ordinary warehouse, with only one frontage, would probably require only one section drawn on a line at right angles to the street, through the entrance and staircase; if the building were considerable, a second one would be required, on a line parallel to the street front. A detached villa, containing a large vestibule, hall, and staircase, entertaining rooms on each side of the hall, a billiard-room and conservatories in the rear, would require five or six sections, one of which would have to be on a line drawn through the vestibule, hall and staircase, a second one across the staircase at right angles to the first, and the others on lines passing through the entertaining rooms, all extending throughout the length, breadth, and height of the building. In all sections the horizontal distances between the walls must, of course, be obtained from the plans, and the elevations must be kept steadily in mind when the vertical dimensions are being plotted. The young architect cannot mistake the number of sections required for any building, if he recollects the rule that every portion of the interior that is not a perfectly plain surface will require a section to illustrate it. The plans, elevations, and sections described above include all generally termed contract drawings.

Extra Drawings frequently required to complete Contract Drawings—Local (or Sanitary) Board Drawings.

But in addition to those what may be called general drawings, others have to be prepared which may be classed as the drawings to be deposited with the local authority—which may be the corporation of a town, a vestry of a district or parish, or the Local Board of a larger area. To these have to be added large-scale drawings and full-sized details in the case of buildings of any importance. And lastly, drawings are often required to be in duplicate, or tracings made of the originals, for the use of the contractor or for that of the clerk of the works. These extra drawings, as they may be classed, will be described in detail in a future chapter.

THE JOINER.

THE GENERAL PRINCIPLES AND THE DETAILS OF HIS WORK.

CHAPTER III.

Joints used in Lengthening Pieces—The Half-lap Joint.

At the conclusion of last chapter we stated that the joints of "Carpentry and of Joinery" were similar in principle: an example of this is found in the illustration now to be given, which forms one of several methods used to lengthen one piece by having another piece added to it. Fig. 12 illustrates a well-known form of joint, known as the "half-lap"; fig. 13 shows this in detail, *l* and *m* being longitudinal sections of the parts *a* and *b* in side elevation; *c d e f* shows in plan the part cut out to half the depth across the line *g h i*, *j k* being the line of junction of the two surfaces. The parts may be secured together by a pin, as at *c* in fig. 14, but this joint is weak to resist any side or lateral pressures, as indicated by the arrow *d*, which will tend to displace the part *a* acting upon the pin *c* as a centre. The lower part of the diagram shows how this lateral strain may be met: the end of the pieces, as *a*, being provided with a projecting angular part, *g*, which goes into a correspondingly-shaped recess or part cut out, as at *f*. Or the end may be formed as at *i j k*; the recessed part as at *k*.

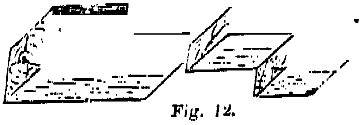


Fig. 12.

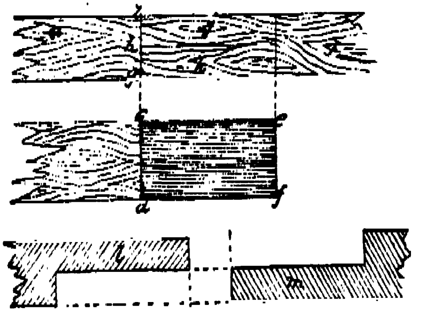


Fig. 13.

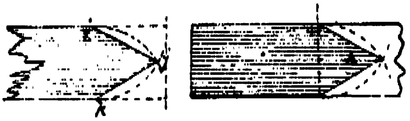


Fig.1

Other Forms of Lengthening Joints—The Dovetail Joint · The Tongue and Groove, or Ploughed Joint—The Ploughed or Grooved with Feather Joint.

Fig. 15 illustrates another joint of the same class as last described, in which the pieces joined with a half-lap joint, as in fig. 12, have dovetail tongues, as at *o* and *e*, which go into corresponding recessed parts, as *e* in plan. Fig. 16 is a modification of this. Other forms of joints in this class are shown in figs. 17, 18, 19, and 20. Fig. 18 is the "tongue and groove," or "tongued and ploughed" joint, the same as used in

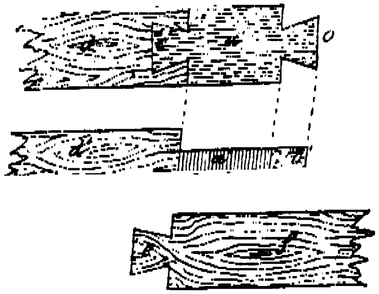


Fig. 15.

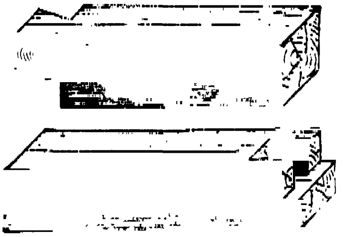


Fig. 16.

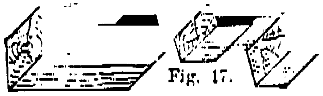


Fig. 17.

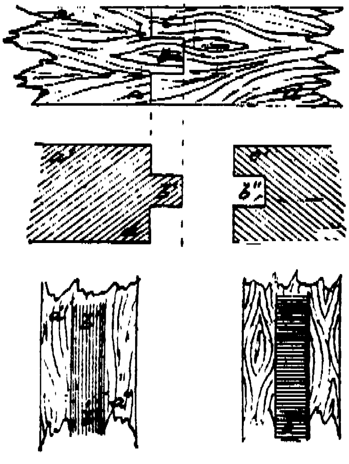


Fig. 18.

joining boards edge to edge. Fig. 19 is a double tongue and groove joint, and fig. 20 illustrates an adaptation of the "dowel" used in masonry (see the "Stone Mason"). The "feather" used, rectangular in section, as *g* in fig. 2, is here, in fig. 20, double dovetail.

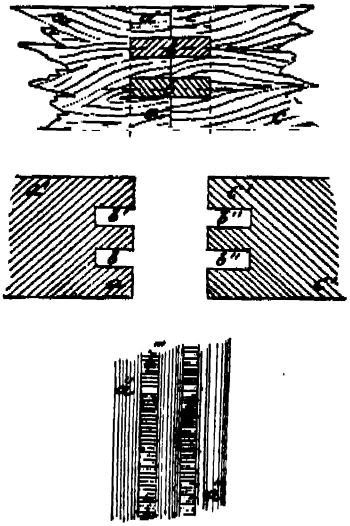


Fig. 19.

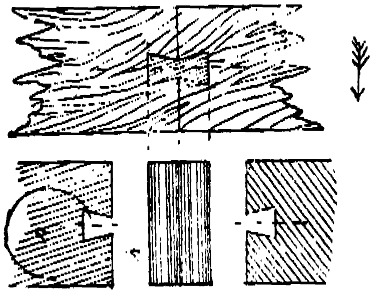
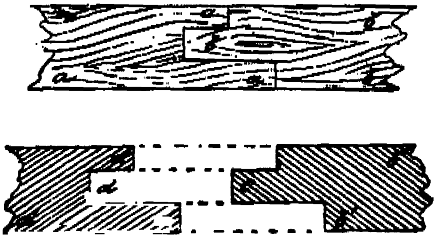


Fig. 20.

Joints used in Lengthening Pieces—Modification of the Half-lap Joint.

Fig. 21 illustrates a joint in this class which may be looked upon as a modification of the "half-lap" joint in fig. 12, *ante*, but in which the projecting part *c* of piece *b b* goes into the recessed part *d* in the piece *a′ a′*. *a a*, *b b*, show the parts put together in side elevation. Fig. 22 is a modification of this with a sloping face or table *c*, and a projecting horizontal part *d*. Figs. 23 and 24 are more complicated forms already described in connection with figs. 5 and 7, of this class of joint. Fig. 25 gives in detail the joint



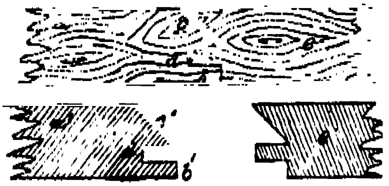


Fig. 22.

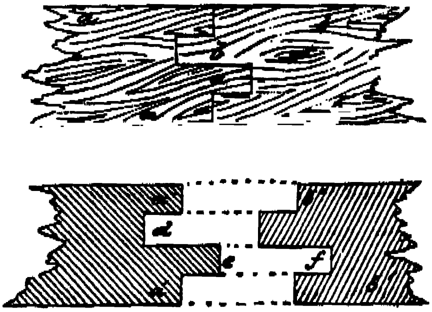


Fig. 23.

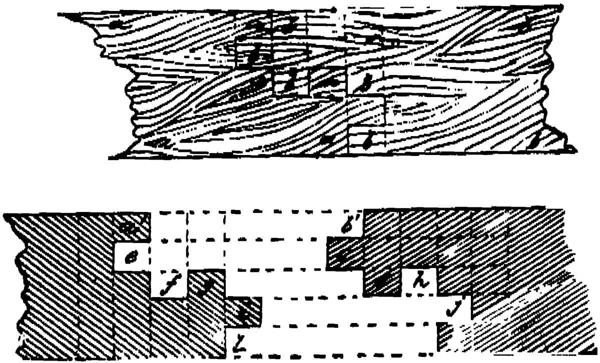


Fig. 24.

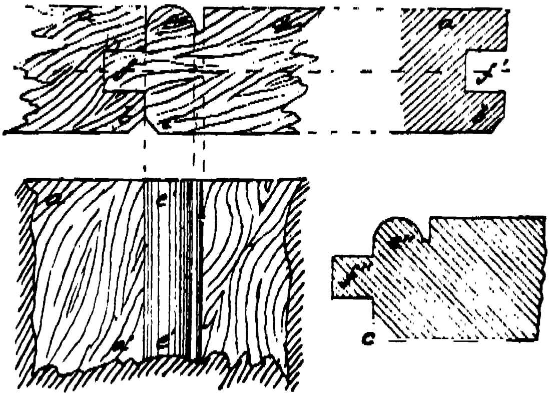


Fig. 25.

which may come under the present class; the corresponding accented letters show corresponding parts of joint. Those joints, especially figs. 23 and 24, come also, and perhaps more accurately, within the range of carpenter's work for large beams.

Tongued, Ploughed, or Grooved Quirk Bead Joint.

Fig. 25 is a joint of the same class illustrated in figs. 5 and 7. The accented letters indicate the separate details to the right. The upper diagram to the left shows the two pieces in edge or side elevation; the lower diagram the front elevation of the pieces. In this only one side or face of the pieces is finished with a quirk bead, as at *e*. The other side is flat, save where the edges of the two pieces are splayed or bevelled—*i.e.* have had the arrises taken off at the joint, as at *b* and *c*. This is referred to in connection with figs. 5 and 6.

Joints used in Joining Pieces Vertically to each other.

We now come to those in which pieces are joined vertically to one another, and those in which the pieces are at right angles to each other.

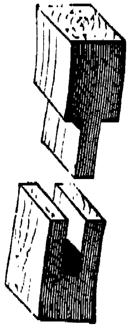


Fig. 26.

Fig. 26 illustrates two pieces joined vertically by what may be called the open mortise, but which is the tongue and groove joint already described. The groove is cut out in the lowest piece, the tenon being cut on the end of the upper piece. Figs. 27 and 28 show the same joint, but for closed mortises—one single, as in fig. 27, and one double, as in fig. 28. In both cases the tenons are dovetailed, not plain as in fig 26.

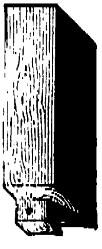


Fig. 27.

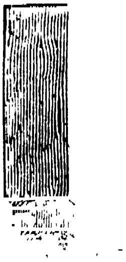


Fig. 28.

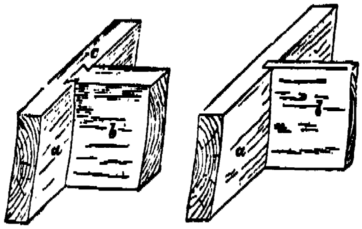


Fig. 29.

Fig. 29 illustrates a method of joining two pieces at right angles: in the upper diagram the horizontal piece is joined to the side of a vertical piece by a dovetail tenon; in the lower diagram a vertical piece is joined to a horizontal-lying piece by being simply let into a groove cut in the lying piece of a width equal to the thickness of the vertical piece.

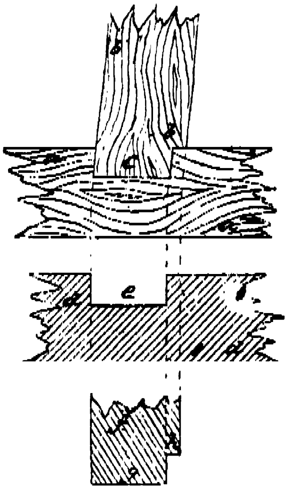


Fig. 30.

In fig. 30 we give a detailed drawing of another method of making a joint, where one piece, as *b b*, is vertical to another piece *a a*. In this the groove is not cut in the piece *a a* of full thickness of the piece *b b*; but only of a certain part of this; the end of *b b* being cut off so as to form a shoulder as at *h*, allowing the part *c* to enter the groove *e* made in the piece *d d*. This shoulder in *b b* allows of part of *b b* butting solidly on *a a*, thus relieving the groove *e* from any lateral pressure exercised by the piece *b b*.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER III.

THE last paragraph in the preceding chapter opened up the general features of the object the cattle breeder had in view, and we concluded by naming the good qualities he desired in his fattening animals. When an ox is found to possess those good qualities we generally alluded to, they are sought to be perpetuated in its progeny; and the breeder, in raising stock from this, the parent, seeks also still further to improve those good qualities, or to add those which are deficient, so that the value of the progeny will be greater than that of the parent. In like manner an animal possessing good points may be made to communicate them, or some of them, to the progeny of an animal deficient in them; so that, while on the one hand good stock can be perpetuated by its progeny, so on the other bad stock, or stock at least deficient in good qualities, may be improved by being brought under the influence of the good stock. This, roughly or briefly stated, constitutes the Art of Breeding.

The Points of Cattle meeting the Conditions Named in Last Paragraph.

The qualities of an ox, or of fattening cattle, are known or designated technically as "the points," and those "points" are indicated by the external characteristics of the frame or body of the animal, these making up what is called popularly its shape or form, but more accurately its *contour*. There are certain other indications of quality of stock which, connected with the feel of the flesh and of the hide, and quality of the hair or fur by which that is covered, are ascertained by what is called "the touch," or popularly the handling or feeling of the animal. To such a point of perfection has the art of breeding reached, that the skilled breeder can so arrange the details of his work that he can lay on flesh, so to say, on the parts of the frame which yield what the butcher calls the "finest cuts," giving the maximum of those, so that the animal when killed yields the maximum of profit. But this high degree of perfection in the art has been reached only by the exercise of the closest observation and the most patient and prolonged of practice, carried on during a very long course of years. Several generations of farmers have passed away since the period when breeding of cattle commenced to be distinguished by that close observation and that patient and sustained effort which can alone raise any pursuit from the position in which it is carried on "anyhow," chance only dictating its results, to that in which certain results are ensured with more or less accuracy, from carrying out of certain rules or methods of procedure.

The Characteristics or "Points" of Fattening Cattle in Detail—Bulk or Size of Frame or Body.

In the preceding paragraph we stated in very general terms what constitutes the art of breeding, and what in the hands of our most advanced graziers and cattle breeders this art has done in creating herds of fattening cattle, which yield the largest amount of flesh or butcher meat, and this possessed of the qualities which bring the highest price for the meat in the market. We also stated in general terms that animals which give this high quality of meat are found to possess certain characteristics of form, or have what is called a good *contour*; those characteristics going by the technical designation of "points." We now proceed to explain those general characteristics somewhat in detail. We have said that the fattening ox has been likened to a machine by which, out of crude vegetable substances, flesh is manufactured. Although this latter term is somewhat coarse in its conception, as applied to that in which the mysterious element of "life" is so intimately concerned, it nevertheless gives a fair idea of what the work of the breeder and feeder of cattle is. For a machine designed to do certain work in the most economical way must have its parts arranged with particular reference to the work to be done, and those duly proportioned one to another. Take, for example, an internally-fired steam-engine boiler, which with its furnace may be called a machine for the production of steam, such as the "Cornish" or the "Lancashire" form (see the papers which take up the details of "The Steam-Engine"). Here we must have ample interior space in which to consume the fuel which gives us the heat, which in time is communicated to the water, which again in time gives us the steam. And there must also, therefore, be ample space to provide for the supply of water, and the steam to be stored up after being produced until it is required. And however those fuel, water, and steam spaces are arranged, they give, and must give, externally a certain form or shape or *contour* to the whole apparatus, and thus a certain bulk or volume to it. A less space for the consumption of the fuel used to boil the water and raise the steam than that which the volume of water demands, would make an inefficient boiler, which would burn coal without giving the proper result or equivalent in steam. Now, the animal frame of the fattening ox may be likened to a boiler and its furnace; and we shall find as we proceed that the simile is much more closely applicable than the youthful student may at present perceive. For the process

The Characteristic Features of Fattening Cattle named in Preceding Paragraphs to be Present in Good Proportion.

In stating that ample space must be given within the frame of the animal for the reception of a large stomach, and of well-developed lungs, it must be remembered that these must be all well proportioned. While healthy action of the lungs is absolutely indispensable, the lungs should not be too largely developed. When we remember that life going on in the animal frame is actually a process of combustion, the food which is the fuel being consumed by contact with the oxygen contained in the air supplied by the lungs, the greater the supply of air to a given amount of fuel—that is, food—the more rapid will be the process of combustion, and the more quickly will the force constituents of the food be carried away by the lungs in the act of breathing. The larger the lungs the greater the area of the air cells, and the more active therefore the combustion of those parts of the food which go to increase the fat of the animal. An animal with too large or unduly proportioned lungs will not take on fat as rapidly as one which has the lungs in due proportion to the frame,—and for the reason above named, for the food will be consumed so rapidly, or the blood will be so quickly oxidised, that much will be taken away which would otherwise have been assimilated by the animal, tending to increase the flesh tissues. The great aim of the breeder should therefore be to have animals with lungs only sufficiently large to admit of the healthy breathing action going on—that is, minimising the combustion of food, leaving its maximum constituents to be assimilated by the animal and form fat. Much the same reason exists for not having a too large liver in a fattening ox; for if it be too large, its action drains off, so to say, the respiratory or carbonaceous or fat-producing constituents too rapidly, and consequently retards the production of fat. Some considerations on these two points, or rather on the one point of undue drain upon the fat-producing constituents of the food through lung and liver action, will be found in succeeding paragraphs, in which the subject of cattle food is dealt with.

"Touch" or "Texture" of the Hide or Skin of the Animal a Test of the Value of Fattening Cattle.

We have already referred to the touch or handling of the animal as a test of the quality of the flesh, this quality being technically known as "texture." This is one of the points or tests of a good animal which cannot be easily, if at all, described in words. What constitutes a good touch or handling of the skin and tissues immediately below it must, in fact, be learned by repeated trials of different animals. The only word which conveys an idea of what a good touch or handling is, is that it shall be "mellow." It is generally understood that the fineness of the touch indicates fineness in the texture or the fibre of the flesh. Every one is but too familiar with the coarse-grained meat which is too frequently supplied by the butcher, which gives a look to the "cut" totally different from the fine-grained, delicate-looking fibre of the flesh of a well bred and carefully fed ox. Fineness of texture or of fibre is often supposed to constitute what is called good quality of the meat. But there is another attribute which goes to make up this essential feature of quality, and that is colour of the flesh. However fine the fibre may be, or texture of the flesh, if the colour be dark the meat is not considered by judges as of good quality. But this, however, may be taken with a reservation, for it may be looked upon as being a point much of the same kind as the preference for white bread to that which is dark-coloured, although this or brown bread may be, and is, considered the more nutritious. We have a parallel illustration in the case of mutton. The flesh of a Welsh or mountain sheep is dark, and quite unlike the light-coloured flesh of a Southdown or a Leicester sheep; yet the texture or fibre of the meat may be alike fine in both, while that of the light-coloured only is admitted to be of good quality. Yet the flavour of the Welsh mutton is highly esteemed. No doubt dark-coloured flesh is not generally so juicy as light-coloured; but a bright colour in the flesh of fattening oxen being considered in general as a point in good quality, the breeder has to look to obtaining this peculiarity in the flesh of the animals he breeds and fattens. He has, therefore, to be careful not to select animals to breed from or through which have dark-coloured flesh, however good their "points" may be as indicating quick-fattening animals.

Principal Breeds of Fattening Cattle employed by the Grazier.

It is not our purpose to give a detailed description of all the classes and varieties which make up what are called the British breeds of cattle: this would demand an amount of space much more in keeping with an elaborate treatise, having abundance of space at command, than with the character of a paper which has to find its place amongst a wide variety of other papers, but which, nevertheless, we hope to make exhaustive enough, so far as the practical details of the subject are concerned. It will be enough for this purpose if we give a short account of the leading breeds, which may be said to be the distinctive, as they are the favourite ones of the grazier. Much has been written, and not altogether of a profitably practical character, as to the aboriginal or original native breed from which all our modern breeds have been derived, that is, supposing—which supposition many writers are by no means disposed to admit as directly based on anything like well authenticated facts—all our breeds to have descended from one primary or exclusive stock. Those who maintain that the present wide variety of breeds, with their great range of diversities of character, could not have sprung from one, but from several original animals, have scarcely, we think, given that close attention to what may be called the influence of the feeding or living circumstances; as of locality, soil—with its food products, and climate, in modifying the physical characteristics of the lower animals. The peculiarities of the pasture grass which alone for many a generation constituted the food of cattle, and which in many districts still practically limits it—have beyond a doubt a peculiar influence on the physical conformation and bodily features of our animals. We see this, indeed, every day now, if we but care to look for and examine it. A bulky Shorthorn or a Hereford ox would starve, where an ox accustomed to feed in the marshy and coarse pastures of Essex, or on the cold hill pastures of the north of England or of Scotland, would thrive. And if we started with a herd of the huge animals, with juicy well filled frames of flesh and fat, on poor pastures and in a cold climate, no one who knows what cattle feeding is, as at once a science and an art, would be surprised to find, after a few generations had passed away, that the animals had degenerated; each succeeding family, so to call it, showing increasing signs of acquiring smaller frames, with poorer meat. And the converse may be taken as true: given an aboriginal or solitary tribe of cattle, by removals to warmer climates and richer pastures, that those cattle would continue to improve, and each class would show some peculiarity which would distinguish it from another class; and that this peculiarity might reasonably be traced to the local and climatic influences.

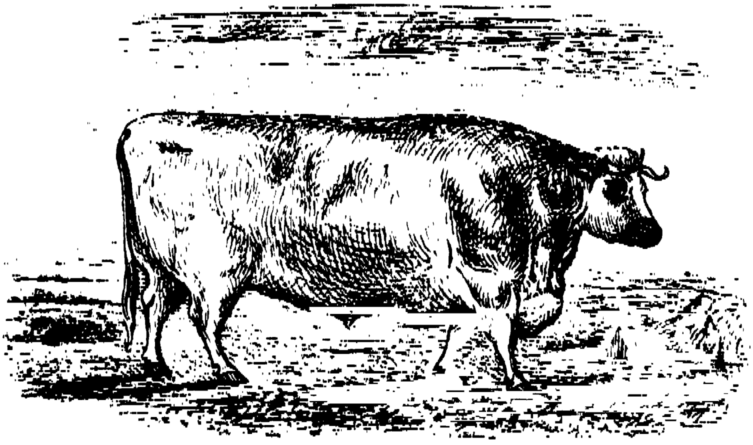


Fig. 1.

While, then, it may be conceded that all our varied breeds have descended from one stock or kind of animal, it is, however, a difficult matter to point out with definite precision what that one class has been. The majority of authorities is in favour of the opinion that it is to the White Cattle, of which we have now but a very few in this country, that we have to look as the progenitors of the wide variety of breeds we now have. And those white cattle are themselves the remains or offshoots of the herds of cattle which in the early periods of British history roamed wild over the northern parts of England, and extended their range to the more southerly parts of Scotland; and hence were called the Caledonian cattle, though why it is not easy to see, inasmuch as they belonged as much, if not more, to England than to Scotland. The only remains of this breed of cattle, which are thus supposed to represent the aboriginal breed of Great Britain, are to be met with in Chillingham Park, Northumberland, at Ribblesdale in Yorkshire, and at Wollaston in Nottinghamshire. Passing from this disputed question as to which was, if there was only one original breed, from which all our modern breeds have sprung—which, however interesting, as it certainly is, in many of its aspects is scarcely practical enough in its details and the outcome of its discussion to detain us longer—we proceed to give our brief notes on the breeds now at the command of the grazier in producing supplies of animal food, or, as it is more definitely termed, butcher meat or beef, for our ever increasing population. And of these we select as the one first to notice

The Shorthorn Breed of Fattening Cattle.

This selection we make on the principle of the descending scale, taking what on all sides is admitted to be the first or premier breed, and therefore considering those other breeds which still, however valuable for the grazier, and holding a high position in his estimation, as not nevertheless ranking so high as the shorthorn, the reputation of which is not confined to this country, but extends alike to the continent of America and to the Antipodes, being as highly esteemed and as eagerly sought after by the breeders of the United States and of Canada as by those in Australia and New Zealand. The "shorthorn" breed is otherwise known as the "Durham," and by this name it is much better known to Continental agriculturists, amongst whom it is held in as high esteem as it is by our own farmers and graziers.

Fig. 1 gives a fairly good conception of the characteristics of the shorthorn breed of cattle—it being an illustration of a prize ox. In a future paragraph the classification of breeds according to the formation of their "horns," as "short," "long" and "middle" horns, will be illustrated, showing the differences in this respect. In the shorthorn in some cases the horn is only relatively short as compared with some animals, of the same breed, which are in reality very short, as will be shown in a future illustration.

THE BRICKLAYER OR BRICKSETTER.

THE PRINCIPLES AND PRACTICAL DETAILS OF HIS WORK.

CHAPTER II.

The Mixing of Soils of Different Qualities in order to make Bricks under Certain Conditions.

THE brickmaker has, however, often to mix his soils in order to obtain the desired proportions requisite for bricks of good quality. And the best mixture obtainable can only be found by direct experiment. However good may be the soil or soils used, it is obvious that all extraneous substances must be removed from them before they are taken in hand for brick moulding and burning. This involves extra care in the preparation of the soil, and we need scarcely say that this is not given where "cheapness" must be the chief attribute of the bricks made, whatever other characteristics of a good kind they may by chance possess. To get rid of useless and dangerous extraneous substances, and to fit the soil for good moulding, "weathering" and "tempering" must be carefully done. "Hand moulding" requires the exercise of skill and care on the part of the workman; but it is fast being superseded by "machine moulding," which not only turns out a greater number of bricks in the same time than can be done by hand moulding, but gives to them a greater density and compactness, and admits of a wide variety of forms and methods of making. After moulding comes the "burning."

The Burning of Bricks—Good and Carefully-conducted Burning essential to the Making of Sound Bricks - Modes of Burning employed.

This demands the greatest care and knowledge. Nor less carefully must the "cooling" of the bricks when burned be looked to, as much of their quality depends upon the way in which this is done. But, however carefully all the previous processes are done, and however good the materials, the "burning" does not give bricks of uniform quality. This will be obvious on slight consideration. Bricks are burned either in specially constructed "kilns"—themselves built of bricks—or in what are called "clamps," which internally are simply structures or masses built up of the moulded and unburned bricks, mixed with which is the fuel which carries on and completes the burning. Now, from the way in which the bricks—partially air-dried before burning—are placed in the "kilns" or built up in the "clamps," and from the way in which, in both cases, the heat is applied to the bricks, unequal burning is the necessary or compelled result. To heat equally all the bricks is the aim of, but never is absolutely secured by, the brickmaker. There are therefore, in each lot burned, different qualities of bricks, and those qualities are defined by the position which they have had in the kiln or the clamp. The best, as may easily be supposed, are those taken from the central part of the mass, where the heat has been most uniformly applied.

Names by which Bricks burned in Certain Ways are Known or Designated.

Those are known by different names in different localities—such as "body bricks," "hard bricks," or "cherry bricks," from their fine, bright red colour. Those bricks taken from the sides and top of the mass are the poorest quality, and, known by various names, such as "soft bricks," "pale bricks," or perhaps more generally as "common bricks," are useful only for the inner courses, being unfitted for outside work exposed to the weather influences, or subjected to heavy pressures, as in superior brickwork. Of kiln-dried bricks, those at the top, or arch bricks as they are generally termed, although hard and possessing a more or less completely vitrified surface, rendering them so far capable of resisting the weather, are generally so brittle that they are unfitted to resist pressure; and mortar does not take kindly to their surfaces.

Bricks Classed according to their Colour.—The Classes or Kinds, with the Characteristics of Soundness.

The above are the general designations of bricks, but there are many special names particularising different varieties according to quality and colour, which attributes are derivable not merely from the materials of which they are made, but from the manner in which and the care with which they are manufactured, dried and burned. As regards colour, there may be said to be three great divisions red, yellow, and blue. It need scarcely be said that the red comprises the great majority of the bricks used in construction; so much so that this colour is, in the popular mind, always associated with the material, and finds expression in the phrase "as red as a brick," as if bricks of other colours were not to be met with. The colour of bricks goes, as may easily be supposed, through all varieties of tones and tints, this being so largely dependent upon the materials of which they are composed and on the way in which they are made. And the tone or tint in great, if not always in absolute measure, indicates with considerable precision the building qualities or value of the bricks. Thus the best of red *bricks* are generally of a bright colour—what is known instinctively to be a bright, pure, clean, clear colour. The best bricks of this kind give out, when struck with the trowel, a clear sound, in great measure metallic, just as if the trowel were striking some material like itself. The surface gives at once the idea that it will well resist the weather influences of rain and damp. Bad or inferior red bricks have, as a rule, what are at once known to be the opposite of the qualities above named, so far as regards colour,

THE ORNAMENTAL WOOD WORKER AND DESIGNER,

In Carpentry and Joinery, chiefly for Exterior Work.

BEING ONE OF THE SUB-SECTIONS OF THE PAPER ON "FORM AND COLOUR IN INDUSTRIAL DECORATION."

CHAPTER II.

At the conclusion of the preceding chapter, in some remarks on recent improvements made in the popular taste in regard to beautiful work, we stated that the cultivation of a taste for the beautiful had a tendency to make people dislike and leave off grovelling pursuits and tastes. And so much has been done in this direction that we have every hope that vastly more can and will be done. It is no vain boast for the advocates of this higher education to say that a more healthy because a sounder notion of what constitutes the beautiful in objects around us, and which we use more or less in daily life, has taken possession of all classes, of all ranks and conditions of men. It has permeated from above downwards till almost the poorest classes display some, and in a few cases even a high degree of appreciation of what is beautiful and pure—which is in the highest degree satisfactory, and which if it be not all that is to be desired, or indeed only in reality but a small advance in the right direction, is nevertheless an enormous advance on what existed a generation ago. The term "art manufacture" now means something, and carries something practical with it, not merely to the halls of the wealthy, but to the "huts where poor men lie." No doubt the term "art manufacture" has been much abused, and it would be well for us if it were not so frequently abused now. Under the shelter or the authority of its name much is produced which, however good its claim to be considered as a "manufacture," has not the shadow of a claim to be classed as "art." Much has been made or manufactured, which in no true sense has been designed. Notwithstanding which, however, it is beyond all dispute, as we have said, that a vast improvement has taken place in the public estimation of what constitutes the beautiful. Even in poor cottages, articles which were supposed to be ornamental, and those which were simply considered to be useful, but all of which were hideously ugly, have been, during the last few years more especially, supplanted by objects which have in many cases some fair pretension to the possession of good design—in some few really do possess it.

Causes which have brought about an Improvement in Popular Taste in regard to Beautiful Things in Construction.

The various agencies which have been at work aiding the efforts of those who desire to raise the standard of popular taste in every walk of daily work, and in every branch of daily life, have without a doubt effected, as we thus see, on all sides great improvement. Our numerous exhibitions have done good service in this respect, not merely as exciting emulation in the various departments of business amongst those who are practically engaged in carrying them out, but they have made us acquainted with what was done by other peoples, markedly those on the Continent. And the lessons they taught us have been so well learned that in some departments we now excel our teachers. But that we have from them much yet to learn, those know best who are best acquainted with what the Continent has yet to teach us. And it is a suggestive consideration, and one which curiously enough bears in the closest possible way on the immediate subject of the present section of this series of papers, that it is just the one which has been the most poorly represented or illustrated in the numerous exhibitions we have held in this country; and to which contributions from the Continent were sent so freely. The art of wood design and execution has, so far as we know, scarcely been represented at all, judging it by the highest standard. And one has to go abroad and travel far and wide, with observing eye and thoughtful mind, before one can form any conception to what a point of practical perfection it has there reached.

Wide Field for the Study of Ornamental Construction in the Timber Work of the Continent.—A Practical Contrast.

And it is only those who have had the opportunities which such observant travel can alone afford, who are able—by having in their possession the power, so to call it, of contrast—to know to its full extent the poverty of our workers in timber in respect to the application of design to the labours of their hands. To one this knowing what has been done, what is being daily done, in countries not so very far separated from our own, makes it, to say the least, somewhat depressing—some would say humiliating—to witness so many opportunities presented to our workmen for displaying their knowledge of design totally overlooked and neglected; opportunities which, if availed of, would in many instances give the people "things of beauty," which the poet has well said are things of "joy for ever," and in all might at all events please the eye and gratify the taste, where now they only offend and shock. This does not hold true only of what may be called the main work of ordinary structures; it holds equally true of the larger and more pretentious structures in which as much money has clearly been expended; some small extra amount of it might reasonably have been forthcoming, to add to all the stability of sound construction which they assuredly display, some at least of the wants and claims of good design. There is a well known city in the kingdom which prides itself, and justly so, on the number and magnificence of its stately structures in the most perfect style of workmanship, and of the finest and purest stone. In this city a public company has erected a structure for the accommodation of the public. Deciding—wisely or not we do not pretend to say—not to absorb much of their funds in the use of material costly to purchase and more costly still to work, they have chosen timber as that of their structure. In point of working plan to suit the wants of the public and of their own business, in point also of soundness of construction, the structure leaves nothing to be desired. But in point of that design which appeals to the taste and pleases the eye, it is, notwithstanding that it faces one of the noblest of streets and one of the grandest of natural objects with which a city can be blessed, neither more nor less than "hideously ugly." True, there is an attempt to give the form or outline of the building some look as if "design" had to do with the origin of the structure; but there has been such an evident forgetfulness—if not possibly an ignorance of the canon or rule in design that each material dictates or ought to dictate its own peculiar characteristic of constructive treatment, that it would have been much more satisfactory if the structure had been even plainer than it is, and been lacking altogether in those details which it possesses, and which are presumed to be decorative. For this very attempt at design serves only to make the lack of all true principles of design the more painfully obvious. A well constructed shell with plain surfaces, and pierced with the usual bald "voids" for doors and windows, would have at least been a thoroughly honest-looking structure, devoid of the pretension which the attempt at design gives to it. And if, as we have shown, the structure in its *tout ensemble* or general appearance betrays a lack of true design, it is scarcely necessary to say that there is an utter absence of design in special details: those details which, when well worked out in design, give a general graceful lightness and an elegance of form which wood or timber properly—that is, artistically or æsthetically—treated is so well calculated to give.

Practical Lessons to be derived from the Foregoing.

We have been thus careful to give the particulars of this example of an important wooden or timber construction, as it presents a fair specimen of what our designers so called in timber construction, and our workmen do, or rather wholly fail to do. It does not stand alone by any means: we could cite many more cases of a like character, but we content ourselves by merely further alluding to the timber "offices" of a wealthy and energetic public society, which in point of design *en bloc* and in detail deserves everything which has been said as to the structure above criticised. And such examples, too numerous as they are, perform what may be called a painful mission, for seen by thousands they perpetuate as it were totally false views of what artistic and æsthetic design should be, whereas they might, differently treated, do much to promote a love or a taste for the beautiful, and add so many more to the educational examples which in other directions—as in our museums, markedly that noble one at South Kensington, and at our technical and art schools—we fortunately have. We have also drawn attention to those examples of how timber should *not* be dealt with, with the special purpose of contrasting the style of treatment so general in this country with that seen on all sides on the Continent. To this we have already made general allusion, to which we may add this special one. In our various rambles abroad we made, amongst other matters of professional interest, this subject a special study in detail, and looked out therefore for every example from which we could obtain hints as to the artistic or æsthetic treatment of the material. Nor had we any difficulty in finding such examples; and we found them, as we have said, not only in places more or less public, and where there was some incitement to the designer to give good work, in view of the larger constituency of critics he addressed, but also in remote districts and in obscure positions where there was little chance of public approval being met with, so that it was simply that love for the beautiful, or that æsthetic taste which will not permit ugly work to be done, which must have been the ruling motive for the execution of the work. Not seldom have we come across some tiny structure of a railway station serving some little hamlet, a mere wooden shed in point of accommodation and size, yet so treated, both in the general design or plan, as well as in every minute detail, that it was a delight to look upon, and could not fail to act as a perpetual teacher, so to say, of what was beautiful in form and outline. The same was observable in domestic structures, some of which were special examples of what were really fairy-like dwellings—so light, so graceful, and altogether so elegant in their general effect. And these were not always ambitious structures in point of the internal accommodation they afforded, the owners of which were possessed of much money to lay out in gratifying their taste. In many instances they were mere cottages, tiny blocks for people evidently of small means; but yet in all of them there was evidence of a love of the beautiful, some of them being specially attractive.

Beautiful or Pleasing Effects in the Ornamentation of Wood Work obtainable at comparatively Little Extra Cost to that demanded for Plain Work.

If it be true that a structure in brick or stone may be built so that it be pleasing to the eye, for an expenditure no greater than that which a house positively ugly in outline would demand; so also in timber it may be held to be true that a pleasing design may be had at as little cost as one unpleasing.

THE WORKMAN AS A TECHNICAL STUDENT.

HOW TO STUDY, AND WHAT TO STUDY.

CHAPTER II.

IN the concluding paragraphs of the first chapter we gave a statement of how the word "art" could be explained. To what we have there said it will be as well if the reader now refers. Meanwhile we proceed to state that the word further means that the proper and perfect doing of the work is dependent upon experience, whether that be of a skill in hand-working, or the result of close observation, or of study in what is popularly called head-work. So that a definition of art may be this: the *doing* of anything with dexterity or skill, just as ploughing or turning up and over of the soil is the doing of the work necessary before the soil is capable of receiving the seed and bearing a resulting crop. And the thoughtful reader cannot fail to be struck with the curious root of a word (art) used every day, in connection with which ploughing is about the last thing thought of. The "root" further carries us back to the times, "hoary grey with eld," in which the very first work man was called upon to do was the production of food from the soil—which gave to this work such an importance, as if it were the only work or art worth while attending to. Nor will the thoughtful reader fail to have some hint conveyed to him, by the linguistic root of the word art, in relation to the manner in which technical education has to be followed if it is to be worth anything at all. On this point, and on the practical lessons which it conveys, we shall have a good deal more to say in the course of these papers.

The reader will thus see how we have so far narrowed the term "technical education" till it is shown to be simply art. And that art for all plain practical, or, as we might say, homely purposes, is simply *doing* work, any work, well; and that the "well" doing depends upon skill or dexterity acquired by experience, by observation, or by study. This in the opinion of some would seem to imply or compel a terrible degradation of the term or word or thing we call *art*, in connection with which the most exalted ideas are held, and the most grandiloquent expressions employed. Yet the fact is, beyond all manner of doubt, that art is simply the doing of work—in other words, the *completion* of something which has to be *done*. And nothing is done till it is completed; and completion infers—and indeed is—perfection of doing, so far as poor humanity is able to do, anything perfectly. It will be odd indeed if now the reader fails to have a somewhat fair conception of how all that we have said bears upon technical education. The only fear is that he will carry with it that to which we have just alluded—namely, that there is some notion of degradation so far as art is concerned. But if he will think it out, there is no such thing; on the contrary, all work to be done—just in so far as it is useful to society—is noble and elevating. It is only work which should not be done, which is useful neither to oneself nor to society, which is degrading.

Further Practical Considerations connected with the Term already explained.

It may seem a somewhat strange thing, therefore, when we say by way of illustration that the simplest work is an art. To dig is an art. Should any one doubt the accuracy of this claim for so humble, so simple a work as this of turning over the soil, let him go into a garden or a field and closely watch several men at work digging. The non-observant, unthinking, would at once decide that this work was, at all events, "purely mechanical, not much mind in it surely—any fool could do that." The observant would, on the contrary, soon perceive that although all were doing the same thing, and all apparently doing it in the same way, there was a decided difference in the style and quality of the work done. The same thing would *not* be done by all. No doubt an ordinary mind would decide that they were all doing, and what they were doing was digging. But if it be true—and this no one would venture to dispute—that work is only *done* when it is completed, and that completion in the absolutely correct sense is dependent upon the work being done well, some of the workers in our supposed case would not be digging in the true sense of the term. To one who knew what good, that is, true digging, is, there could be no doubt that some were doing "bad" work not worth paying for, and to whom it could be said—as is often in similar cases in daily life said "I would rather that you would cease working, if you can give no better work than that." Others of our imaginary diggers would, on the contrary, give work which, even to a not very quick eye, could at once be seen to be quite different from some of the other work, which one would almost intuitively know from the very look of it—being shipshape or workmanlike—to be "good" work. And even in the class of good work there would be a gradation in result—some being better than others—while to the work of some one could without hesitation apply the term "best." Here, so far from our imaginary gang of diggers doing all the same thing, we find that they are in fact doing very different things; at least, if it might be said that they were all digging, they certainly were digging in different styles and giving very different results. Nor would it be found that—although doing, as was said, all the same thing—they were doing it in the same way. It would not, indeed, take much observation to perceive that some would do their work, such as it was, in such a manner as to demand great physical exertion, "larding the lean earth" as they dug along; while others would work with such ease that, compared with the others, their work would seem more like play than anything else. And one thing might be said to be the fact—that, as a rule, those who worked with the greatest ease to themselves would give the best work; and if inquiry were closely pushed, it would also be found that those who did the best work had acquired skill, dexterity, and consequent ease, by patient thinking out of what their work really was, and no less patient practice in doing it carefully, till what was to them a difficulty at first became an easy thing ultimately.

Completeness or Thoroughness in the Doing of any Work, the following out of any "Art," essential to Success.

We have purposely devoted some space to the considerations in the preceding paragraph, as they involve much that is of vital importance in the matter of technical education. They bear closely upon the practical outcome of the definition of the term technical education we have arrived at from a tracing out of the meaning of the term technical, which, as we have seen, embraces more than one point. Whatever objection may be made to our definition of technical education—namely, that it is simply the "doing of a particular class of man's work well" or thoroughly—it will be admitted that it at least possesses this advantage, that it is simple and easily understood by all: while it may reasonably be claimed for it that it is really correct. For, no matter how high any given work may be in the scale of art, no one can deny that the act of doing it involves work, labour, or effort of some kind. But we venture to go further, and maintain that this definition—simple and accurate as we hold it is—carries with it principles or a principle of the very highest practical importance to the workman, be he one who is engaged in what may be the very humblest of handicraft work, or in carrying out what may be the highest developments of thought, skill, and dexterity. This principle is thoroughness or completion. What we have written will have been given in vain if even a somewhat careless reader has not perceived that the very germ of any "art"—and we have seen how wide the scope of art truly defined is—the foundation on which it rests, is "completeness." No work, as we have shown, can be said to be in the truest, the practical sense of the term, *done* till this completeness is effected. If we go to nature for our lessons—and let some men (they are not, fortunately, many) say what they will to the contrary, she is our best, most suggestive, and patient teacher—we shall find that she does nothing in a half way. To use the common expression, everything she does or makes is "rounded off"—that is, finished—nothing is wanting. And this is seen in her simplest, as in her most complicated productions. And let it be observed here, as worthy of special regard, that this completion carries with it the essential features of true dignity of purpose. There is nothing mean about the works of nature. One never associates what we call shabbiness with any of her works. Each one appeals with direct force to the conscience, as it were, of the beholder, in such a way that there is no thought of protest; the object carrying with it such a conviction of truth as work well done can only secure. And how those appeals are—while powerfully made—not seldom made with a tenderness and a depth of feeling, let the close students and lovers of nature say, as they best of all can say. Now, this completeness involves thoroughness. This we find exemplified even in common speech, for do we not on examining good, the best work—especially on comparing it with other—say almost involuntarily, "Ah! now *that* work is 'thoroughly' well done." The two attributes are, in fact, synonymous, or the one involves the other; for you cannot have complete work without thoroughness: thoroughness—or, to use the phrase tautological, yet graphic, of a practical man, "thorough thoroughness"—gives completion, or, as we otherwise say, "finish" to all work.

The Definition or Meaning of the Term "Art" involves the Idea or Principle of Thoroughness in the following up of any of its Departments.

The very meaning of the term "art" involves or carries with it this perfect conception of thoroughness. This is shown when we go below the surface, so to say, of the word itself. Now, "art," the full or extended meaning of which we have shown to be simply expressed in one word, "work," is—as we have already hinted at—derived from or based upon the Latin root *ar*, to plough. Hence the term "arable" land that is, ploughed land. Now, let the reader who has not given much thought to what is involved in the meaning of words, and of how much that is of the highest practical value in daily life can be "dug" out from them, consider what *this* derivative means. What is meant by ploughing? Well, we confess that it is possible for some readers to have had little experience of country life. Not quite so ignorant of its work, we should hope, as a very clever artisan, who asked the writer of these lines, who was taking the really clever fellow round his garden, "What are those fine green plants with such pretty white flowers?" The honest fellow, no doubt, had eaten in his day pecks of the produce of them, for the plants he knew not were green peas, in all the loveliness of their blowing stage—and only a lover of nature can say *how* lovely they are. Not quite so ignorant of country life as this may some of our readers be, yet they may know so little of country work as not to know in what ploughing really consists.

THE TECHNICAL POINTS CONNECTED WITH THE EMPLOYMENT OF FORM AND COLOUR IN INDUSTRIAL DECORATION.

CHAPTER II.

At the conclusion of the first chapter, as illustrating the point that true decoration does not interfere with the nature or utility of form, we cited the case of a boat, and after drawing attention to certain points of this, we stated that none of its useful attributes must be done away or interfered with. While, therefore, we must not encumber its surface with forms which, however beautiful in themselves, would still be excrescences, so that its speed be interfered with, we must not pierce its sides with apertures, however graceful in outline they may be, through which the fierce waves could pass to endanger its safety. Now, however absurd such illustration as this last may, by some of our art student readers be considered, this much we may safely say in its favour: that it is not more absurd than illustrations taken from objects daily manufactured and sold to a placid public as articles of art manufacture of high value as artistic productions. If the reader will but think of and draw upon the stores of his observation, he will have no difficulty in bringing up the recollection of objects of art manufacture so called, which will amply justify our illustration as being as absurdly decorated in relation to their uses, as a boat would be with its sides pierced with ornamental apertures.

The Principles of Surface or Flat Decoration.—Outline and Colour.

Having thus directed the attention of the art student to the great principle which should dominate all his work in the direction of the form of solid bodies, or in "the round" as the technical term is, we now take up in like brief manner the subject of the decoration of *Flat Surfaces.* This is, of necessity, one which has a very wide range of objects. It embraces the decoration of walls, or of the paper pasted on them, which modern taste seems so universally to demand; it includes the whole range of textile fabrics, such as the carpets we cover the floors of our dwelling-houses with, and this with not always a strict observance of sanitary laws, and the numerous fabrics used in the clothing of our persons —the calicoes, the woollen goods, the silks and the velvets, as also the laces, which, if they do not always adorn the forms of beauty, serve, as cynics say, to minister to the love of display and foster vanity. So far, then, as to the scope of the subject.

The art student must at this stage take note that a very important point enters into the discussion of this subject of art treated as flat surfaces. Hitherto we have had only to consider the subject of form or outline. So also in the department under notice form or outline is to be taken notice of; but another element comes also into existence as influencing the practice of decoration of flat surfaces—namely, *colour.*

The subject, then, divides itself into two departments of treatment—first, the outlines giving the form, shape or configuration of the flat surfaces, and second, the colour with which those surfaces are decorated or filled in. The student will of course understand that there are some subjects or designs which are in pure outline only—that is, upon flat surfaces—which designs are not coloured; just as there are some designs which are coloured, and it is to these last that the principle above indicated is applicable. But preceding the notes on coloured form, the illustration of the points connected with pure outline or flat surfaces only will first engage our attention.

Of Pure Outline or Form.—Principles of Decoration.

Here the principle to be borne in mind may be stated thus. In a piece of well concerted music the notes must, so to say, flow into each other, so that no jarring discord be created—in other words, they must harmonise. So in forming any outline or configuration—or "pattern," to use the popular phrase—the lines making this up must flow into each other in such a way that, to employ the expression above used, they must "harmonise." What we mean here by lines harmonising will best be explained by the following: Lines must flow into one another, so that when they meet, the junction of the two must not produce any harsh lines, such as a bend or knee or projecting part, as in fig. 2. This is further illustrated by the ornament called the "Greek honeysuckle," or *anthemion,* in fig. 3. This, the lower portion (*a*), we call the husk, and from this all the lines spring, each one of

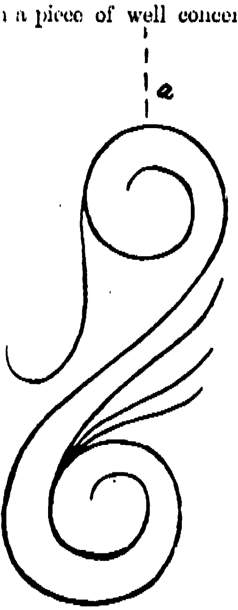


Fig. 2.

which flows into the husk in such a way that it would not if produced or lengthened either cut into the body of the husk, or proceed to the centre. When properly drawn it is compelled, so to say, to flow into the husk. In fig. 4 we give an illustration of the Assyrian *anthemion*, or honeysuckle. In the Greek form of this ornament the leaves or lobes are not uniform, but vary up in some instances to as high as fifteen, being decided apparently by the caprice or will of the designer; but in this the same principle of drawing the lines is carried out, so far as the ornament itself is considered, or rather its details.

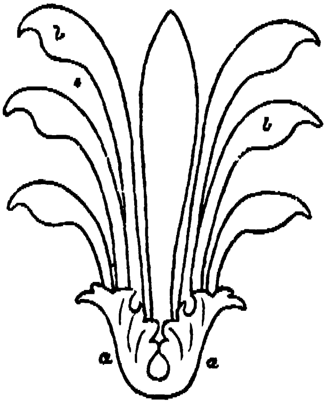


Fig. 3.

In the Assyrian *anthemion* the number of lobes or leaves is always seven—three on each side of the central lobe *b*—while the three lobes *c c* are joined as in the sketch fig. 4, not separated, as at *b b* in fig. 3.

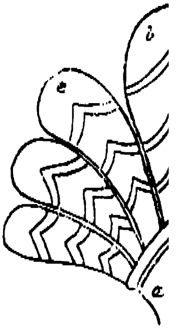


Fig. 4.

The lobes also in springing rise from a disc *a*, and not from a husk, as at *a a* in fig. 3. And each lobe is cut up or ornamented by the lines shown, which is called the water-mark. In fig. 5 we give another form of the Greek *anthemion* or honeysuckle ornament. In this the lobes *a a* do not spring from a husk, as at *a a* in fig. 3, but from *b b*, the central point, *c*, between which terminates with a point as that of a leaf. The student must take special note of the principle here involved, inasmuch as it applies to the whole work of ornamental drawing of outline subjects. What is here true of the simple subject, as illustrated, is equally true of all subjects, however complicated. This important principle the student will find exemplified in any ornamental drawing *correctly* done he pleases to examine, but for the younger of our readers we have illustrated it by the foregoing sketch, fig. 3. A more detailed drawing of this will be found in its proper place in the companion series of papers entitled "The Ornamental Draughtsman." In the simple sketch given in fig. 2 the young student will see how, if lines were incorrectly drawn, in place of flowing into the main line they might shoot off if produced or lengthened in some direction at any point, as shown, say at the dotted line *a* in the sketch. If he will also look amongst the subjects illustrating "The Ornamental Draughtsman" for that study in which the Greek scroll is first given, he will find this importance of harmony of lines further and most conclusively illustrated. Further illustrations and hints as to what is the technical part of ornamental drawing, or the manipulative execution, the pupil will find in the letterpress descriptive of the plates and figures given in the paper entitled "The Ornamental Draughtsman." So also he will find in succeeding chapters of the present paper illustrations showing the application of the general principles of design to what is called manufacturing or industrial art, and further description of the points now in this chapter enforced.

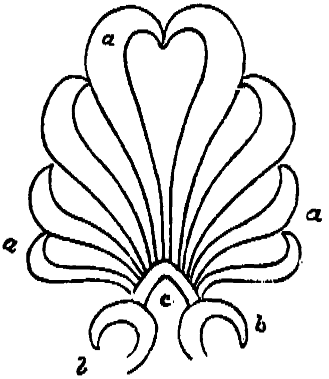


Fig 5.

Colour in Decoration. Importance of the Subject.

In the preceding paragraphs we have directed the attention of the reader to various points connected with the application of form to the decoration of various objects. We have yet much to say on these points, but our remarks will come in more appropriately when we take up their practical application to various departments of decorative work, such as paper hangings, textile fabrics, as ribbons and printed calicoes and furniture stuffs, etc., etc. Meanwhile we have, as introductory to those subjects, and also as illustrative of various points of importance in itself, now to take up the subject of "colour."

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER III.

General Statement as to the Proposed Mode of Treatment of the General Subject of the Present Paper.

AND here, before proceeding to give our remarks on the leading subjects of our papers, a few words we deem necessary as to the method in which they are arranged, and of the principle on which that arrangement is for the most part based. That principle may be briefly described as taking up the subjects in what we consider to be their natural sequence. For example, there are certain terms which are met with in nearly every mechanical description, which are concerned with and named repeatedly in the enunciation of every mechanical law, and which terms indicate *conditions* without which no arrangement of mechanical parts or combinations can be made to do mechanical work. These terms we take as the starting point of our disquisitions on the natural laws on which all mechanism is dependent, and which give existence to, modify and control the condition of all the materials which are used in the construction of machines, and of all the substances with which machinery in industrial work has to deal. And as we proceed to describe what those terms are which are used in connection with mechanical devices or constructions connected with them, we shall find that other terms indicating other natural laws and conditions flow, so to say, naturally and consequentially out of them. These in turn we shall take up and consider, and those in turn will have other laws and conditions which in like manner proceed from or flow out of them coming up also for consideration; we shall thus by an exhaustive process take up and deal with all the points connected with the natural phenomena affecting or rather underlying all the work with which the practical mechanic has to deal.

Further Considerations of a Practical Character connected with the Proposed Mode of treating the General Subject.

And here, as explanatory in some degree of the way in which we shall carry this arrangement of subjects out, and for other reasons which shall presently be obvious, we deem it necessary to allude to what may be called a special characteristic of the present times—namely, a tendency which seems to our mind unfortunately a growing one, to discuss and consider mechanical subjects or laws which deal obviously and alone with material, or as they may be called mechanical points, in an abstract way, which is almost if not wholly metaphysical. We are of course far from maintaining—which to maintain would be simply absurd—that mechanical laws and considerations do not involve points which are intellectual, and being so, must to a certain extent involve those connected with metaphysics or the science of mind, otherwise and often termed "mental philosophy." It is scarcely necessary to say that on the contrary we hold, what is in fact incontrovertible, that the study of mechanics and the laws which regulate its practical work, involves and demands the exercise of the highest intellectual or mental powers. But what we particularly refer to in the above statement as to the present tendency of discussion of mechanical subjects is the application to it of that branch of intellectual training which is best known by the name we have applied to it—"metaphysical." Now, without in any way detracting from the value of metaphysical disquisitions, or, as we may put it, logical argumentations, we may in all modesty declare that in the application of this method to the discovery of mechanical laws, and subjects dependent upon those, a danger is likely to arise of great practical moment to students, and of those especially the youthful.

Danger arising to the Student of Mechanics from loosely indulging in Conjecture or Hypothesis as to certain Natural Phenomena.

What this danger is we shall presently very briefly allude to, more special illustration of it being met with in succeeding paragraphs. Without attempting to be very precise in our definition of the characteristics of the metaphysical method of discussing subjects, we may with some safety decide that Metaphysics considered as a science has as a rule to do with "abstract" thought,—Mechanics as a science with "concrete" considerations. These terms here placed in inverted commas may be explained in a way quite practical enough for our present purposes when we say that Metaphysics may be said as a rule to deal with conjectures or hypotheses—Mechanics with facts. Engineering, which is but a more comprehensive term for the last named science, has been, and as we think, as truly as aptly, termed "the science of observation." Now, in the truly practical sense we can only observe facts—that is, the condition in which things actually exist around us, and which we can make available in one way or another, and adapt to the working purposes of daily life. And it is upon the facts which a long succession of generations of mechanics have observed that the magnificent structure, so to call it, of mechanical and engineering work we see everywhere around us is based and has been reared. Now, the danger which we fear is likely to arise—has, indeed, arisen in the experience of more than one youthful student of mechanics—from the tendency to discuss and decide mechanical subjects metaphysically, that is, by the aid of assumptions and conjectures, or to use the more learned term hypotheses, is created in this way

It is admitted on all sides—what indeed could not, with any show of reason, be denied, however pleasing to the vanity of man if it could be denied—that there are in connection with a pretty wide variety of what we call scientific subjects, some things of which we know nothing, that is, we cannot say *what* they are. Some of these things have been already named, so it is not necessary farther to allude to them. But if we do not absolutely know what those things are, we may however conjecture, in other words guess, at this. No one could for a moment dispute the right of any other to say what *he* thinks such and such things are. But what is the right of one is clearly the right of all. Hence we may have, in connection with but one natural phenomenon or class of phenomena, not one but several kinds of conjectures, or a great number of guesses, or what may be called theories. In such cases the right or the learned word to use is "hypothesis," and this means practically a guess. It is derived from the Greek *hupothesis*, which means a thing "placed under"—in other words a supposition, this word itself being derived from two Latin words, *sub*, under, and *ponere*, to place. If we have, for example, a body before us, we can see it, handle it, and possibly, if not too heavy, move it: the body itself is what we call a fact, about which no one disputes so far as *it* is concerned. It is there, and there it remains to stare us in the face, asserting itself the fact that it exists. But if, not content with this, we desire to know what it *is*, what it is absolutely and truly composed of, and we find on examination that there is such a peculiarity about it, that while one says it is composed or made up of one thing, another says another, and so on, we would scarcely blame one who came forward and said 'You *know* absolutely nothing about it,—and if you were aware of the fact that generation after generation of men had passed away all of whom had been trying to find out what the body was composed of, but could not, you would not be surprised to be told that you not only do not know now, but very probably never will know.' Now, all that has been said about this supposed body, as to what it is or is composed of, are called "hypotheses," suppositions, or guesses; and the same holds or may hold true of what can be done with the body or how it can be used, seen, handled or moved. Take the moving of the body, for example—which is done say by the hands pressing on it, by exerting what we call the power or force of the arm. One finds that he can move it, and this power we in like manner have agreed to call by the name of force, and in this instance the muscular force or the power of the body. Why these names are given we shall see presently. But when men begin, just as we suppose they did when trying to tell what the body was, of which they knew nothing—to try to tell what this something they agree to call "force" is, we find that one says it is this or caused by this, another that and caused by that. And so one may come forward and say, as before 'You *know* nothing about it in reality, any more than you know about life what *it is*, and are not likely ever to know.'

But while it is not given to man to know certain things about bodies or substances (and it is those with which the mechanic has to deal), enough is given him to know about them, their properties, and what they do, or, as engineers say, how they "behave" under certain circumstances in which man places them: in other words, all the phenomena or facts concerning them. Now, do not let the youthful reader suppose that we deprecate the attempt to explain what those substances really are, we mean in this their ultimate or final cause, or what those influences really are—to which we have given certain names—which bring about or cause certain effects, which we call phenomena. It is not merely a legitimate exercise, but it is a beneficial exercise for the mind, to make suppositions, form conjectures, or frame hypotheses, or what are called "theories," to account for all those phenomena about the circumstances of bodies or substances: nay, more, hypotheses or theories have a positively useful place. All that we now contend for is, that in things and upon points which every one admits we know nothing absolutely certain of, and therefore only conjecture or guess about, we shall not insist upon *our*, or any one's conjecture we may espouse or support, being correct, and that simply because we ourselves believe in them, we expect that others shall do so also. But we would go further, and say that as we have, fortunately for the progress of man, *facts* enough about bodies and substances which we do positively know, for we have the evidences of our senses in proof of their existence in a very marked, and not seldom in a painful way, —it is the wisest thing to do to frame hypotheses or propound theories which fit in so well with facts that the common sense of nearly every one tells them that there is nothing incongruous or contradictory between them. And further, that no demand is made by the theories upon the mind to believe in and understand things which, from their very nature, and indeed from the very words and terms used to describe or explain them, common sense as a rule tells us are in reality beyond the comprehension of most minds, simply because this same common sense tells us that we cannot positively be certain of their existence. Now, the very diversity of opinion to which we have alluded is shown in many of what are called theories of mechanics, and in this very diversity lies the proof that men know nothing absolutely of what the theories are based upon. Men do not dispute about what every one is agreed about: two and two every one knows to be equal to four, and as all believe in this no one disputes it.

THE BOAT AND SHIP BUILDER.

OUTLINES OF THE PRINCIPLES AND PRACTICE OF HIS ART.

CHAPTER I.

Introductory.

FROM the title to this series of papers as above given the reader will perceive that the scope and scheme of the subject is comparatively limited. And this we desire to draw attention to at the outset. For if more than an "outline" of the principles and the practice of the art of the boat and the ship builder were attempted, we should be committed to a much wider subject, demanding a far more extended space, than either the character and aims of the TECHNICAL JOURNAL or the space at command will admit of. Nor need this be matter of surprise when the exceedingly wide range of subjects to be noticed, the importance and complicated nature of their principles, and the number, the almost endless character and diversity of the details of actual working practice, are considered. When the fact is here alluded to, which to those acquainted with the subject is familiar enough, that even a moderately complete, but far indeed from a thoroughly exhaustive, treatment of the art and the science of boat and ship building demands a volume of no small bulk, and that ponderous quartos and portentous-looking folios have been written upon them, the reader will at once conclude that, however great the anxiety of the writer of the present series to present him with a full and moderately exhaustive treatise on a subject so wide, the very nature of the present work precluded all chance of his being able to realise his wishes, and that, therefore, he was, however regretfully, compelled to limit his papers to an outline only of the principles and practice of the art. But on looking at all the circumstances, alike those connected with the special character of the TECHNICAL JOURNAL and those of the bulk of its readers, it is not so much a matter of regret that the present series of papers will only be this "outline." For it is to be remembered that to a large extent the Journal is designed to be a help to beginners in the study of the subjects which will occupy its pages; those subjects being expressly introductory to *many* who have not previously been acquainted with them, or if they were, possessed only the most meagre and limited of information. The various papers are designed to be largely educational, although much will be given in them, if only in the way of hints and suggestions, valuable to those having a wider, if not a thorough knowledge of the subjects, and who may also be engaged in their practical work. Nor must this fact be overlooked: that while claiming for our paper the character, and with it the apparently limited nature of "outlines," those outlines will be found, it is reasonably hoped, very full and complete, considered as such. They will in reality comprise a fund of information as to the principles, and embrace a variety of details in the practice, of the art of boat and ship building, that to any reader carefully studying them this promise may be safely made, without much fear that it will not be realised—that he will possess more than a mere general knowledge of the art; in reality a very fair conception of what its practice is, and how he can apply it usefully.

Some Considerations of Technical Value connected with Inventions of the Boat and Ship as a means of Conveyance from Place to Place.

There are few branches of the work of man in which what are called mechanical principles are involved, which when traced back to their origin do not afford much that is interesting, and (what is of more consequence to the practical reader) that is usefully suggestive. It is not always, in truth but very seldom, that we are able so to retrace the successive steps which man—generation succeeding generation—took in perfecting any one branch of his manifold work, till we at last arrive at the first advance which was made, and the dominating idea or conception of the work, and how the leading characteristics of the mode in which it was likely best to be effected was obtained. Some of the most essential contrivances in the doing of mechanical work, such as the crank; some of the most useful of our industrial machines, such as the potter's wheel, have their invention or origin so shrouded in the mists of bygone years, that all we can say we know of them is that we know nothing. Let us go back as far as we can, to the times in which facts and circumstances were recorded in one or other of the forms of hieroglyphics, sculpture, or in the more evanescent written words: we find that certain mechanical contrivances were then in daily use or so treated as well known things, that of them the expression so often used is almost literally true—that they have been known for, have existed from, time immemorial. And in this connection it is worthy of all careful notice by the young reader, as if only he endeavour to think it out, it is suggestive to him of much that will be of value to him in the conduct of his working life, that we know nothing of the origin or what *may* be called the invention of even such simple mechanical contrivances as the nail, the screw, the carriage-wheel—with which man has been so long familiar that their value is thought nothing of, although that is simply priceless. Even granting the means of permanently recording the time when such simple contrivances were first thought of, and the man or men with whom they originated, or the period at which, by successive steps, more complicated contrivances were brought to such a condition of comparative perfection that they could be used with certainty and effective purpose, the truth would seem to be that those who in the case of a single, and what we in the long acquired security of its possession call simple and deem not even worthy of a passing thought, or the succession of men who brought more complicated contrivances to useful perfection, thought very little indeed of what they had done. So little that probably they never named their work even to their neighbour, but simply allowed a knowledge of it to be spread abroad in the ordinary natural way of others observing it, and adopting it, simply because they saw what was of use to another could be useful to them. The first inventors and improvers probably thought no further of what they had succeeded in doing than that it facilitated their own work and rendered labour not only lighter, but possible, which before had been difficult to be done, or not likely to be done at all. We find the same thing existing now amongst us, and evidences not a few are to be found in proof of it, that most ingenious, most useful mechanical contrivances have been, to use a familiar expression, unearthed by some one accidentally becoming aware of their existence; and the same can be said of discoveries in connection with some industrial or chemical processes. Their inventors or discoverers have in reality in such cases thought little of them, their chief concern in the matter, as indeed their only satisfaction, being that they were useful to them in their own particular labour; and dreamed but little of the fact that if only known they might be useful to thousands of others in their work. Inventors and discoverers nowadays have, it is true, the reputation, not by any means charitably accorded them, of being vain and over-sanguine as to the wonders which their inventions and discoveries are to effect; but it is just as true that there have been inventors, not a few, just as humble-minded, who have done good work, of which the world had remained ignorant, had not circumstances called in the language of the world chance—better put in the words of the old poet, "but that chance the good God did guide" —brought them to the knowledge of those who at once saw their value to the world at large. There are but few of long extended experience and observation in daily technical life but who have come across at least one instance in proof of this; and if there be, as some say, little doubt, there is at least fair ground to decide that this accounts largely for the fact that we know so little of the early history of those inventions and discoveries to which the world is much indebted.

Another point highly suggestive to the young technical reader is that some of those mechanical contrivances now appear to us so very simple that we are apt to conclude that they were invented and discovered at once, springing, so to say, at once into perfection—"Minerva-like, all armed from the brain of Jove." But from all that we can learn, certainly from all that carefully examined analogy teaches us, the truth seems rather to be that, even in the case of simple contrivances which some one has called "units of invention," it took a long series of trials, extending over many years, to bring them to the condition in which we now find them. Thus, take the case of a carriage-wheel or that of a common barrow. Simple as this appears to be, it is the conclusion of one of our highest mechanical authorities that it took generations before it was finally elaborated. That this was likely, the young reader may conceive if he attempts to trace the steps by which the wheel was brought into existence. From the time when—and for long it would be so in the earlier stages of man's existence—he would laboriously drag, say the trunk of some prostrate tree, from where it had fallen to some spot where he wished to make use of it (see the papers under the head of "The Carpenter" in this Journal), by sheer force of his muscular strength or that of his own and of others combined,—it might be by design or some fortuitous thought that he would gain something by it in the way of making his work and that of his neighbours more easy of accomplishment, that he placed under the huge and heavy tree trunk the boles or branches of trees of comparatively small diameter. But it is much more probable that those got placed by accident. Anyhow, it would be found that, so placed, the heavy tree could be dragged over the ground with greater ease than before, when there was no smaller trunk or branch or branches below it. The idea, then, of the "roller" would for the first time be obtained—a simple enough contrivance, truly, but one which plays at the present day so important a part in such an extremely wide range of technical and industrial work, that its value is beyond all computation. By shortening the roller—that is, by cutting up our supposed original form of it, the branch or bole of a tree, into a series of short lengths—the form of circular or round, and more or less thin or flat discs, would be obtained. And when once the idea of boring a hole through one of these and then passing a pin through (one of smaller size than the hole), and securing the pin to a fixed point, the wheel capable of revolving on the pin, as its axis, would be obtained. And if, as may be reasonably assumed, the *hand*-barrow, or simple wooden platform with projecting handles at each end, and used to carry objects from one point to another, had been before discovered—and even this, simple as it is, is a mechanical contrivance involving design—if the flat disc was firmly fixed on its pin or axis, and this pin made long enough and small enough at the ends to pass into two holes one made in the end of one handle of the barrow, the other in the other handle opposite, the *wheel*-barrow would be invented, by which a man could trundle along by himself, not waiting for or requiring the help of a neighbour, as in the use of the hand-barrow, as great a weight as before, and with greater ease. An analogous case in the steps taken by which useful appliances to lighten human labour and facilitate its accomplishment were gradually brought to a useful point may be seen exemplified when we glance very briefly at

Some of the Points of the Invention of a Boat or Ship.

A tiny boat floating lightly on the water appears to be a very simple thing indeed. So simple, that of the great majority who look at or use it for pleasure or for business, not one in a thousand—and, for the matter of that, this last figure might safely be multiplied by ten—ever gives even a passing thought as to what it really is, and to all the marvels of human knowledge, and of long tried years of patient endurance, of risks of accident, of dangers to life and limb—in brief, to all the real romance which the boat in its history as an invention or discovery involves. Looking, indeed, at all points of it, it may well be concluded that of all that man has found out—and through all his history it has been true, as the patriarch of Uz in the plains of Syria said thousands of years ago of him, "that he hath found out many inventions"—not one gives greater evidence of what he can do than a simple boat. The more we look at it and endeavour to penetrate what are the secrets of its birth and development till it has become the beautiful and perfect thing we now know it to be, the more we are inclined to agree with Ruskin—of all "word painters," as writers of his high stamp are called, the highest—when he says, "There is an infinite strangeness in the perfection of the boat; as a work of human hands I know nothing else," he continues, "that man does which is perfect but this. All his other doings have some sign of weakness, of affectation, or ignorance in them. They are over-finished, or under-finished; they do not quite answer the end, or they show a mean vanity in answering it too well." He is here writing, the reader should note, of a simple rude fishing boat, with its blunt head or prow. And of this he continues: "But the boat's bow is merely perfect, complete without an effort; the man that made it knew not that he was making anything beautiful, as he bent its planks into their mysterious ever-changing curves. It grows under his hands into the image of a seashell, the seal, as it were, of the flowing of the great tides and streams of ocean stamped on its delicate rounding. He leaves it, when all is done, without a boast. It is simple work." But, as elsewhere in the same paper Mr. Ruskin says, "That rude simplicity of bent plank that can breast its way through the death that is in the deep sea, has in it *the soul of shipping* . . . the sum of navigation" is in it. "Then also it is wonderful on account of the greatness of the thing accomplished. No other work of human hands ever gained so much. Steam engines and telegraph indeed help us to fetch and carry and talk; they lift weights for us, and bring messages, with less trouble than would have been needed otherwise. This saving of trouble, however, does not constitute a new faculty, it only enhances the power we already possess. But in that bow of the boat is the gift of another world. Without it, what prison wall would be so strong as that white and wailing fringe of sea? What maimed creatures were we all, chained to our rocks Andromeda-like, or wandering by the endless shores wasting our incommunicable strength, and pining in hopeless wealth of unconquerable waves! The nails that fasten together the planks of the boat's bow are the rivets of the fellowship of the world. Their iron does more than draw lightning out of heaven—it leads love round the earth." We make no apology for giving here those beautiful words, embodying, as they do, no less beautiful and suggestive ideas. They will not only give to our readers who are interested directly in ship building and in shipping a higher and more ennobling conception of their craft, but will be read with pleasure by others who only read these papers for general information and for that love of all things connected with the sea which is in very truth the heritage of all Englishmen. For we are essentially a sea loving, a sea traversing people; its waves give us music as they boom their billows on the rocks which gird our island home; the winds which, sweeping over them, shriek in the ears of other peoples so wildly, but whistle tunes aloft to our hardy sailors as they pace below the decks of the ships which are their pride as they constitute their strength. To our sea-going enterprise and daring we owe all or nearly all that wealth of power and position which has made us the masters of the world, of an empire on which the sun never sets. And all this has come out of and from that simple thing in the eyes of many, a boat—by whom first thought of, first made, how, when and where made, we know nothing. History, however earnestly and beseechingly inquired of, is all silent as the tomb.

Origin or First Elements of the Boat.

But although history is all silent as to where the first boat was made and launched, and still more so, if that be possible, as to how the first conception of it arose, and how the idea was practically carried out, still conjecture is left us as to what were the probable steps by which, from the simplest elements, the first and rudest boat was produced. Such conjectures may by some be thought practically useless, or at the best only interesting and perhaps suggestive; but we hold them, in instances such as the present, to be highly valuable. For if they do nothing else, they urge and promote thought, and this leads to observation of the world of facts and circumstances around us. And throughout as yet in the pages of this Journal, as we hope will be one of its features in the future, we have maintained, whenever opportunity has offered, and will maintain, we trust, when it again offers, that the habits of observation and of thought are of essential value in all technical work; without which that work will be of the poorest, but the career of him who possesses them not of the most unsuccessful. Conjecture, then, as to the origin of the boat may take more than one, if not many directions: it may take this. Man would learn immediately, by the habit of observation, the first power which could point to him the way of every discovery of things and facts new and before unknown to him, that of all the objects by which he was surrounded, stone if thrown into water would sink, and wood would float in it. And if living by the banks of rivers he would see, in times of flood, trees and branches of trees rush past him in the wild whirl of its waters. And now and then he might see, securely standing on the surface of some larger tree than usual, often half submerged, but still as a rule above water, some living thing, as a dog or sheep, carried down by the flooded water from some district above that in which he lived; and now and then two or more trees with interlocked branches, affording a wider surface than that given by a single tree, on which might be piled up a confused heap of pieces of lesser-sized trees or of branches, straw and other things—and yet again, above all, and securely carried along for the time, some living thing. He may before, having learned from the first that wood would "float" or "swim" (see a paragraph presently to be given, in which the scientific meaning in relation to the art of boat and ship building will be explained), have trusted himself to some trunk or large branch of a tree, and, half supported by it, half swimming, paddled himself across some broad river. But as small trees could be more readily got, because more easily cut or dragged down, and as the result of thinking out what he had observed in the things swept past his hut on the flooded river, as above described, he would see that by joining small tree trunks or branches together, and adding to their depth by piling one upon the other and binding them all as securely as he could with rushes, withes or wands—the first vegetable fibre "ropes" man had at command—he might get a something which, when floating in the water, might do more than transport himself: might carry himself and his neighbour, and perhaps some of their simple goods and chattels, across the river in safety and dryshod. This the first realisation of the "raft" would give him very practical conceptions as to bodies floating or swimming in water, and capable of being moved from place to place. But the "raft" would possess some qualities which would make it less useful to the early pioneers of civilisation. Its very weight would make it difficult to be moved, in some cases at all, by the power at hand; its form, if moved, would make its motion slow and not easily and readily guided and controlled; while its power or capability of carrying heavy loads, while very useful in some great emergency, or on solitary and special occasions, would not be required in the great majority of instances, where what would be needed would be something which would carry himself only, though without fear of drowning him in the water, and which could be moved along, paddled or somehow propelled, with little muscular exertion, and the form of which would not hinder, as that of a raft would do, but would facilitate, its passage through the water. The trunk of a tree would again be reverted to, or originally taken up; and probably taking a lesson from the fish, which he would now and then catch by hand in the river, or from some of his own actions or movements in swimming—for man would probably learn very early to swim, as the only means at first of crossing deep waters—he would taper off the front part of the tree, to give it a sharp beak; and in time learn the value of doing the same, although to a lesser extent, at the other termination—though for long it would only be made sharp at both ends like. Thus the first conception of a "canoe" would be obtained. But it would be solid, and it would probably be some time before the value of a hollowed-out trunk of a tree as adding to its swimming or floating powers would be perceived. The hint of it might be given by observing the conduct, or, as engineers say, the "behaviour," of objects naturally hollow or substances enclosing an empty space,—such as he would have if, after sucking the savoury contents of the egg of some wild bird which he found, he threw away the empty and partly broken shell into the pool or the river beside him, where it would swim, that is not sink, at least for some time. But it is possible that, without any thought of such a process helping to increase the floating power of his solid tree canoe, but simply from a desire to make it more convenient for one or other of his purposes as affording a safe and secure place to carry small objects he might take with him in his long voyages, he might first level the upper side of his trunk canoe, and proceed to hollow it out. And he would in time perceive that the more he hollowed it out, the more obvious relation there would be between the hollow and the power of floating of the canoe. Be all this as it may, and however probable it is that at a comparatively early period man saw the advantages of making a canoe or boat capable of carrying weight safely across water in times of calm, hollow with their sides not scooped or burned out from the solid, it is certain that it would be long, and only after patient trials, that he would be able to realise his conceptions. And this if for no other reason than that it would be long before he had tools and appliances so perfect as to cut out and prepare the planks, and to bind them to the curve or shape he desired; and means, moreover, of firmly securing them together, so as to retain the form and position given to them. When we come to look at the actual construction of a boat, we may be able more clearly to see what were likely to be the steps taken by early builders to arrive at its construction. Having thus given what we feel will not, at least for our younger readers or those unacquainted with the principles and details of the art, be useless or unsuggestive, we proceed at once to the consideration of the matter of the next paragraph,—

Boat and Ship Building at once a Science and an Art—Certain Definitions and Terms connected with the Science necessary to be known by the Reader.

Ship building, using the term in its broadest sense as including boats and floating vessels of all kinds, demands an acquaintance with certain principles, and which having to be known constitute its science (for definition of the term "science" see the paper entitled "The Workman as a Technical Student—How to Study and What to Study"). These principles are based upon natural laws, and are therefore fixed and invariable. But ship building is also an art: it demands work to be done in accordance with certain rules and practices, though those are under the influence of circumstances which are ever changing, and are themselves brought into existence largely from experience, so that what is done to-day to effect a certain object may to-morrow be proved to be, if not the worst, certainly not the best or the right way to effect that object. Hence the art of the work to be done in ship building has been a steady series of changes and fluctuations which so far exist now that there are yet many points in which practical men are not agreed, and which scientific men are yet debating. All this is almost equivalent to saying, what of course every one knows to be the fact, that the progress of ship-building has been one of continual changes, the great majority of which have been improvements; so that each generation finds itself in advance of the one preceding, and the next hopes to be better than the present. What are the fixed principles necessary to be known—that is, those based upon the laws of nature, which never vary—will now be attempted to be explained as fully as the nature of our plan and the extent of our space admits of. This we shall do by taking up certain terms used in ship building, and define those and such others as grow as it were out of them. In the series of papers given under the head of "The Technical Student of the Principles of Mechanics" the reader will find, in the various paragraphs which treat of the "centre of gravity," the principle which affects the stability of bodies resting on *solid* and immovable surfaces, according to the position of the centre of gravity in relation to their base. He will there also see how, while bodies may be overturned by changing the position of the centre of gravity by some force or another, other bodies having bases of peculiar form may be acted upon by a force or by forces so that by change of the position of the centre of gravity the position of the body while changed does not lead to a complete overturning of it; but on the force or forces being removed the action of the centre of gravity in seeking to return to its normal position brings back the body to its original position, carries it beyond this for some distance, and this being repeated, what is called a "rocking motion" is produced.

"Floating"—"Swimming" of Bodies, in Water.

When we come to consider the physical phenomena of bodies placed not on solid and stable surfaces, but in a mobile vehicle, such as water, we shall find that the principle which affects the stability and constructive utility of bodies resting on solid surfaces affect also the constructive utility of those which rest in a mobile fluid, such as water. In such a case the term rest is not as a rule—is, indeed, seldom employed, but the body is said to "float" in the water. The term, it is curious to note, is derived from the French *flotte*, or the German *floss*, or possibly the Anglo Saxon *flota*, all of which signify a river, just as if our ancestors in the earliest times had discovered—as it is exceedingly probable that they did discover—the principle or characteristic of floating by observing the conduct, or, as mechanics would say, the "behaviour" of bodies cast into or found in rivers or streams. The other term sometimes employed in connection with bodies existing in a mobile vehicle, as water, is "swim," and as a mechanical term it is in frequent use, as when a body placed in water is said to "swim fairly," —that is, that it is well balanced, or, as is also sometimes said, it "sits well in the water." The term "swim fairly" is also in mechanics applied to moving bodies or parts of bodies in motion when they are so well designed and constructed that the motion is easy, without vibration, jolts, or jars. Although the term "swim" is derived from the German word *swimmerei*, to float, it is universally considered to involve the idea of *motion* in a floating body; hence the term "floating" is that which is applied to bodies resting in and near the surface, and which do not sink to the bottom or below the surface of the water, although it is true that a body which is swimming must also be floating.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER III.

We concluded the last chapter by pointing out that the defects in the drawing-board surface caused by the drawing "pins" could be in a measure remedied by a little appliance. This generally is made of a small circle of pure horn, or of other substance nearly, if not quite, transparent, and soft enough to allow of the point of the compass leg penetrating it sufficiently to give a hold or firm footing. The circle is provided on its under side with three very short but sharp pins, so placed in the disc as to form a triangle. Those pressed into the paper at a point right above the centre of the circles to be described give a fixed and hard surface in which to work the compasses. But as we look upon prevention as better than cure, we should advise the young draughtsman not to use drawing pins to secure drawing paper to the board in a quick way, or for temporary purposes. If used at all, the only time at which we think their use permissible is when the sheet of paper used is so large that the corners are quite close up to the corners of the board. In this position, though the "drawing pins" do press and make holes into the board surface it will not so much matter, as their position will be such that they will rarely or never be at a place where circles or measurements are to be made or taken by the compasses.

The Permanent Method of Securing Paper to the Drawing Board by Damping, Gluing or Gumming—generally known as the Operation of "Stretching."

We now come to the fixed or permanent method of securing drawing paper to the board. This is known as the "stretching" method, and when paper is so fixed it is said to be "stretched,"—a term not applied to the other methods we have just described, which are simply alluded to as being fastened or secured. The stretching method is dependent upon the fact that fibrous or textile materials contract or extend or stretch or "draw in," in proportion to their hygrometric condition, or what is popularly said to be their damp or dry state. In carrying out the stretching method of fixing paper to the board, the sheet of paper is laid flat upon the surface of the board, with its finished surface—if the two faces or surfaces be differently finished, such as one side being glazed, the other dull—placed under, or next to, the board. With a sponge, which should itself be clean, dipped in pure water, and squeezed out so as to be perfectly damp or wet, yet not "dripping" or "dropping" wet, go over the whole surface of the paper. If a sponge be not within the reach or the pecuniary means of the young draughtsman, a piece of soft linen or cloth, such as an old or well-washed and worn cotton handkerchief, will do almost equally well for moistening the paper. Some lads are so poorly provided with money that the having a sponge even, or doing without it, makes a difference to them; so that it is always advisable for them to set their wits to work to devise economical expedients, in order to make the best of their circumstances; and they will be none the worse, but all the better, for the discipline. It not seldom happens that those who struggle through want in their early days are so successful in their maturer life that their success is far beyond their hopes or even wishes. There is, even from a technical point of view, a vast deal to be learned from the familiar, and as some people would call it, the vulgar proverb, contained in the saying, "like the old woman who never wanted, because she always took that which she had at hand." In no callings is the habit so valuable of resorting to expedients to find substitutes for what cannot at the time be obtained, as in those of building and engineering. After this digression, not altogether without its practical technical value, we proceed with our description.

Principle on which the "Stretching" Method of securing Paper to the Drawing Board depends.

The object in moistening the paper is to have its whole surface so carefully gone over with the damp or wet sponge or cloth that every part of it shall be equally and also thoroughly moistened or made damp, so as to be perfectly flaccid or "limp" throughout. What is wanted, as the ultimate condition aimed at by the process, is that each part of the paper shall be equally and uniformly stretched. And this can only be secured by having the paper equally damped, as the stretched or final condition of the paper depends upon the equal contraction, and this cannot be secured unless it be equally damped or moistened in the first instance. To obtain this condition, or rather to be certain that it will be obtained, the sponging should be done so evenly that the draughtsman feels assured that he has gone over every portion of its surface. To which end let him begin at one end or side of the paper, say the left-hand end, and take one sweep of the sponge right to the other or right-hand, taking the next sweep, starting from the left hand again, a little lower down the sheet, till the bottom or lower edge be reached. Dashing at the sheet, as some do, beginning at any point, as mere chance or thoughtlessness dictates, and rubbing the surface over in any fashion, is not likely to gain the object in view. If a thing be worth doing at all, it is worthy of being done in the best way possible to the doer of it; and to the doing it in the best way nothing is so conducive as "order" and "method." And he will find that order and method are essential to the attainment of proficiency as a draughtsman, and certain it is that if he be careless of order in small and what he deems to be unimportant things, he will be so in matters which he may consider important. Nothing, be it noticed, however, is unimportant which has to be done (see the papers entitled "The Workman as a Technical Student—How to Study and What to Study").

Practical Hints on the Damping and Stretching of the Paper on the Drawing Board.

The damping of the paper will be best done if the sponge be moderately, not too wet, as much water is apt to make the paper rise in parts, and be blotchy and uneven in the surface. It is, therefore, better to go over the surface several times with only a moderately wetted sponge or piece of linen, giving a little space between the spongings, in order to allow the moisture to penetrate the surface equally. The draughtsman can, by looking across the surface of the paper as it lies on the board, easily see whether all parts of the sheet are wetted or not; and when it is thoroughly limp, the same method will show him that the surface is so far dry that no shining wet part is visible on it. For this must be its condition before the next part of the process is to be gone through. This is the reversing of the sheet, so that the side which has been sponged is made to lie nearest the board, the unsponged surface being now the uppermost one. The "reversing" of the sheet may seem to some young draughtsmen to be a process so easily gone through that it may be done, as the phrase is, "anyhow." But, like everything else which has to be done, there is a right and a wrong way to do it—a bad, a good, a better, and the best. It is good discipline for the young draughtsman to aim at doing the best in all his work, and if he aims at this in small, he will be sure to do so in more important matters. The best way, then, is to take hold of the upper edge of the sheet near each end, and as he lifts it up from the board, to lift it so that it becomes freely suspended or hanging down. In this suspended state, and lifting it clear from the board, the sheet must be placed so that the other side and its lower edge touch the board surface near the upper edge of the board, when the sheet is gently lowered; keeping it bellied in the while, till the upper edge, by which it is held in the hands, comes in contact with the surface of the board at its lower edge. All this, which is much more quickly done than here described, is necessary if it be desired to have the sheet placed in its final position on the board without a crease; for if the sheet should be taken up carelessly to be reversed at one point only, as we have seen some young draughtsmen attempt to do, the creased or crumpled condition in which it will lie on the board will be anything but satisfactory.

Practically Useful Hints on the Best Way of Handling, Lifting, or Examining Sheets of Paper or Sheets of Finished Drawings.

And here it will be useful, while on the subject of the handling of sheets of drawing paper, to point out to the young draughtsman the proper and the improper way of lifting drawings or sheets of paper. You will see one taking up a sheet to look at, or hand to some one, with one hand only, and that very probably—indeed we may say it is done generally—at the extreme corner of the sheet. He evidently trusts to the thickness of the paper that it will give sufficient stiffness to the sheet, that it may be taken up and looked at just as if he was taking up a piece of very stiff and thick cardboard or a piece of flat wood. No doubt, the sheet of drawing paper may be, and is generally, stiff enough to allow of its being lifted up with one hand and at an extreme corner. But only for a time will the paper remain extended, the leverage exerted by the weight of the whole sheet, acting at one corner, tends to bring down the sheet so that it begins to droop, to counteract which the holder almost instinctively gives the sheet a bend with his fingers so as to partially corrugate it, and by corrugation to give it such a strength as will sustain it somewhat extended, either to be looked at or handed to some one. But at what expense has this been attained?—at that of the integrity or proper condition of the sheet itself. For this mode of handling almost of necessity gives the sheet a bend, or wrinkle, or break, which is permanent, which no treatment can get rid of. Not seldom have we seen careful draughtsmen disappointed and chagrined by seeing a drawing of a most elaborate kind so lifted by some careless, thoughtless fellow, as to give the treasured sheet such a bend that the flat, uncreased condition which all good draughtsmen love to see their drawings in, and which *they* are so careful to keep them in, was wholly and for all future time lost. So also will careless draughtsmen spoil at the very beginning, before a line of work is put upon its surface, a good sheet of paper in lifting and handling it in order to use it for some purpose or another. Such is the improper way of handling drawings or sheets of paper. The proper, the truly *mechanical*, and if the reader will permit us to apply a great word to a small thing, the scientific way of doing this "little thing" is this: Take hold of the sheet with two hands, a slight hold being taken at each diagonal corner, that is, at opposite corners, the left hand holding the lowest, the right the highest corner; and when so held, in lifting the sheet hollow the central part to hang down precisely like a chain, which will so bring, if suspended at two points distant from each other a length less than that of the length of the chain. The curve which both the sheet of paper and the chain assume when so held is called, indeed, the "catenarian curve," from the Latin word *catena*, a chain

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

40. The Bessemer Steel Manufacture.—The Soaking Pit Process for Ingots.

THIS is one of the most recent improvements in working up the steel ingots produced by the "Bessemer blow," and it promises to effect as great a revolution in the manufacture of steel rails, bars, etc., as the Bessemer process effected in the making of steel itself. As the reader will find explained in the articles in the text under the titles "The Steel Maker" and "The Iron Maker," a large amount of expenditure is incurred in the erection, the maintenance and the working of what are called "re-heating furnaces." Those in the ordinary methods of working up of the original masses of iron and steel into rails, bars, etc., are required in order to bring up the temperature of the metal at certain stages of the rolling, etc., processes, the initial or primary heat of the mass being too far exhausted to admit of the process being finished. The new process, so far as Bessemer steel is concerned, enables the initial heat of the ingot, as it is taken out of the ingot mould, to be so economised, or rather dealt with in so special and effective a manner, that steel rails can be made or rolled into a finished bar without any process of re-heating being required, as is generally now, and up to the date of the introduction of this process was universally, the feature of the trade. The process is due to the inventive genius of Mr. John Gjers, Engineer, of Middlesborough, the capital of the celebrated Cleveland Iron District, whose name is highly and most honourably associated with a number of most valuable improvements in the mechanical technics of the iron and steel manufactures. Like many other valuable improvements in working out different processes of manufacturing industry, the idea of this, "the Gjers" system of rolling steel ingots with their own initial heat, is simple, and the method of working "extremely easy and practicable."

Excess of heat in the primary condition of Bessemer steel ingots over that required for working or rolling them is one of their peculiar features which has often, by various inventors, been attempted to be availed of, but without success till this system was introduced. Those who have witnessed the "Bessemer blow" in actual work, will have a most vivid recollection of the intense heat possessed by the steel as it is poured into the ingot moulds, and equally so of the condition of the ingots when taken out of the moulds, especially if they have been standing close up to the Bessemer ingot "pit." Suffice it to say that at this stage the temperature of the ingots is far in excess of that required for a rolling or working "heat." And even the tyro in such matters will understand how the heat, taken as a unit or whole, must be unequally distributed throughout the ingot at the time it is "stripped"—as the process of taking it out of the ingot mould is technically termed. After it is set sufficiently, or solidified, the interior will thus be in a much more highly heated condition than the exterior, and while this may be too cold, or just cold enough, to fit the ingot for the rolling process, the interior may be too hot. We use the term "cold" in its relative sense, for it cannot be in any way applied to ingots of steel passing through the working processes in the ordinary or conventional sense, as all know who have even but a slight personal knowledge of the working up of steel ingots into rails. It is just this inequality of temperature possessed by ingots worked up under the old, or, as it may be called the present re-heating furnace system, which is the cause of one of the many noted defects of rails made by it. For it may almost be said that it is practically impossible to get a mass of metal which is heated in a re-heating furnace of equal temperature throughout; for if kept long enough to have the interior heated to the point necessary to obtain good rolling or working, the exterior will of necessity be over or beyond this point in temperature. In the case of Bessemer steel ingots, if they are kept long enough, so that the interior cools down to the point best fitted for working, the exterior will be, of necessity, below this point. The re-heating furnaces demand, therefore, for their working, the exercise of great care; hence the necessity to employ a superior class of workmen, whose consequently higher wages add materially to the necessarily great cost of the system. By the Gjers soaking pit process all the disadvantages, pecuniary and otherwise, are to a very large extent, if not wholly, certainly generally done away with.

We now glance briefly at the principles of this most important improvement in Bessemer steel ingot working. At first sight it would appear to be a comparatively easy thing to keep the ingot, with its over-heated interior, in such condition that the heat economised or treated would be equalised over the whole mass—this uniform temperature being that best suited, as we have just seen, for working it up into rails, etc. To many it seemed to be so easy, that numerous attempts were made to utilise the initial heat of the ingot, the chief feature of which was the conserving of it by surrounding it with non-conducting substances or shielding it from the unequally cooling effect of currents of air. But all those attempts were unsuccessful in securing the desired end. Some of our readers may remember the attention which was attracted some twenty years ago or thereabouts to what was called, if we remember aright, "the Swedish Cooking Stove." This, in fact, was simply a wooden box, the inside of which—lid or cover included—was lined with a very perfect non-conducting material. When a covered vessel containing cooked or warm or boiling solid or liquid food was placed in the interior of the so-called "stove," and this carefully and effectually closed up, the effect of the non-conducting material was such that the initial heat of the body or mass of food in the vessel was conserved, and this so well that after the lapse of many hours the vessel might be taken out of the stove with its contents, if not at a temperature nearly equal to its initial heat—at least, so little practically below it that the food would be hot enough—"steaming hot," as the phrase goes—for eating, almost as if it had just been brought from the kitchen. But more than this: Suppose the vessel containing the food was placed in the so-called "stove" at a very high, say boiling temperature, but with the meat not "quite cooked," the heat at first given out by the vessel and taken up partly by the non-conducting material with which the stove was lined, and partly by the air between the sides of the vessel and the stove, was, as time went on, given back again to the vessel and its contents, so that after the expiry of a certain period the food could be taken out not only still hot — "piping hot," as another kitchen or cooking phrase goes—but completely cooked. This simple apparatus, the idea of which is met with in a still more simple appliance—the woollen "cosy" of the tea-table—gives a very fair notion of the principle and arrangement of the "Gjers Soaking Pits for Bessemer Steel Ingots." The soaking pit is, in its simplest form, a chamber lined with refractory fire-brick—that is, brick capable of withstanding an exceedingly high temperature without breaking up or disintegrating—hence the term "refractory" (see the "Cyclopædic Dictionary of Technical and Trade Names" for this term—section "General Science"). The inside or cross-section of the pit is slightly larger than that of the ingot, to allow of its being easily dropped into its place in the event of any projecting parts of metal—technically called "fins"—which might be left in the bottom of the ingot. The height or depth of the pit may be six up to eighteen or any number of convenient inches in excess of the length of the ingot. For the facility of working the pits, they are all constructed below the level of the ground floor of the Bessemer pit, where the ingots are made; and for removing the ingots from this, and dropping them into the soaking pits, all those are commanded by an "ingot crane," and this, further to facilitate working and save labour, which is money, commands also the position at which the ingot is to be passed to the rollers of the rolling mill. Before the working of the ingots, which are to be taken from the ingot moulds to the soaking pit, and from thence to the rolling mill, commences, it is necessary that the interior of the soaking pits should be brought to a red heat. This is done by placing hot ingots in them. When properly heated, the regular working of the system begins as thus. The ingots are to be taken out from the moulds as soon after pouring as practicable, so as to have the highest degree of initial heat. They are then swung round by the crane, and dropped at once into the "soaking pits," and each pit as it receives its ingot is covered with its lid, made of refractory materials, thus practically keeping out the air. Surrounded by brickwork surfaces at a temperature as high as themselves, none of their heat is allowed to escape, and after remaining some time "soaking," so to use the inventor's expression, in this heat bath, the heat becomes uniformly distributed throughout the whole mass. And, as a consequence of the retention of the heat within the interior of the pits, it follows that the temperature of the ingot mass is increased, so that the ingots when taken out of the pits to be swung round to the rolling mill—which is done after they have been soaking from twenty to thirty minutes—are actually hotter than when they were put into them. But it is obviously necessary that the brickwork of the soaking pits should be kept up to the same temperature as that of the ingots placed in them. This desideratum is secured by a surplus of ingot heat, which is left over from the loss of the initial heat due to it when it is first taken out of or stripped from the mould. This loss is caused first by radiation when the ingot is exposed to the air before it is put into the soaking pit; and secondly by some part of it being absorbed or taken away by the brickwork after it is placed in the soaking pit. But when the system is well carried out, the surplus of heat from successive ingots keeps up the proper working temperature of the soaking pits. This may be utilised in another way. For just as we saw in a preceding sentence that the heat given back from the Swedish stove to the vessel containing food was sufficient to cook it completely—so in the case of the Gjers soaking pit, should an ingot be detained by some cause or another in its way from the mould to the pit, so that it gets colder than it should, the surplus heat, so to say, of the soaking pit is given out to the ingot, raising it to the temperature required. The walls of the soaking pit may thus be said to be an accumulator of heat, storing up what is not wanted at one time to be given out at another when it is. While the ingot is "soaking," as above explained, it passes out from its mass volumes of gas. This acts—in addition to the refractory cover or lid of the pit—as a "seal," still more completely excluding the atmosphere by its continual flow through the opening round the edges of the lid, for while this gas is passing out the young reader will perceive that no air can pass from the atmosphere outside. This gas is combustible, as is shown as soon as the lid of the soaking pit is taken off, by its flashing into flame on mixing with the ordinary atmosphere. In the ordinary re-heating furnace the metal which is being brought up to the required working temperature for a succeeding part of the working process—it having lost its heat when passing through a preceding part—is apt to be, and in practice very often is, deteriorated in quality by being oxidised in the furnace, from which it is obviously quite impossible to exclude the oxygen of the atmosphere. If, then, the gas produced in the soaking pit by the ingot itself, and which we have seen is combustible, contained oxygen, it would have a bad effect upon the ingot material, burning or oxidising it. But, fortunately for the perfection of the process, the gas of the soaking pit is a perfect non-oxidising medium, being composed of hydrogen, nitrogen, and carbonic oxide only—of which an analysis showed the percentage per volume in the order just stated, H. 27·21, N. 59·91, C.O. 12·80 (1). A German scientist, who has been experimenting with the system, gives the name "heat-equalising process" to it, objecting to the term "soaking" of the inventor, inasmuch as this implies a softening of the metal extending from the exterior to the interior of the ingot—whereas, as he states, there is only one equalising of the temperature throughout the mass. The same practical authority shows conclusively that the Gjers system of utilising the initial heat in working up the steel ingot without any re-heating process being necessary is a success. Thus contrasting it with the ordinary, and at present general, system—which, however, it bids fair in time to supplant—this authority shows that while by the soaking (or heat equalising) systems, to produce 100 tons of finished, well made steel rails, 114 to 118 tons of ingots are required, by the re-heating or old system the number rises from 118 to 123 tons. While no fuel is required for the soaking system pits, from 20 to 40 tons of coal are required for each 100 tons of finished rails made by the old system; the number of burnt rails by the re-heating process being five, while there is *no* loss from this cause by the soaking system. The advantages of the latter do not, however, end here, for no account is taken of the capital saved by the soaking system which is required in the old process, as no expensive re-heating furnaces are needed; while the cost also of the gas "producers" (see the series of papers in the text entitled "The Furnace Builder"), by which the "gas" is made for heating the furnaces, is also saved. Further, the cost of maintaining those in good working order is saved by the adoption of the soaking system; finally, a less amount of costly labour is required by it as compared with the old or ordinary re-heating process. With all these advantages, the reader will not be surprised to learn that the adoption of the Gjers soaking or heat-equalising process is steadily on the increase. One large establishment in the United States in which it is carried out, shows that six pits are capable of turning out 150 tons of ingots per day of twelve hours, at a cost only of about 1½*d.* per ton.

41. Schaffner & Helbig's Process for the Utilisation of Alkali Waste.

In connection with our Note No. 5, and the correspondence thereon, we think it well to supplement the subject by a curtailed description of the process itself, without committing ourselves to a decided opinion as to its ultimate commercial success, further than that contained in our letter above referred to.

This process was patented in March 1878, but was not extensively tried till about four years after. It is theoretically a perfect process, but in practice the pecuniary results are not quite so satisfactory. The alkali waste consists chiefly of sulphur and lime, derived in the Leblanc process from the decomposition of common salt into the sulphate by means of sulphuric acid, and the subsequent conversion of the sulphate into carbonate by means of limestone and coal. The lime from the limestone and the sulphur from the vitriol are ultimately entirely lost, and form "alkali waste." The recovery of these materials, or the utilisation of this waste, has called forth a large amount of talent, time, and capital, but not with perfect success. Of the several methods tried, and many more suggested, those of Schaffner, Mond, MacTear, are the most important. The method devised by Schaffner and by Mond, independently of each other, consisted in partially oxidising the "waste," and then adding hydrochloric acid, which precipitated a portion of the sulphur in the free state, which was collected, washed, dried, and used as sulphur. This, however, only recovered about one-third of the total amount of sulphur present; and the large amount of acid required in the process, amounting to about four tons of acid, at sp. gr. 1·15, to each ton of sulphur obtained, was an objection to its general adoption. By Schaffner & Helbig's method 90 to 95 per cent. of the sulphur is regenerated, and in the form required by the alkali maker—namely, vitriol. The following is a description of this process:

The alkali waste is collected in large tanks with as much expedition as possible, as one of the peculiarities of the process is that exposure of the waste to the air, partly oxidising the sulphur compounds, causes them to resist the subsequent processes. In these tanks the freshly-drawn waste is treated with solution of magnesium chloride, in quantity slightly more than is required for complete decomposition. The best strength of solution is 1·15 specific gravity. The action which now occurs is that the sulphur contained in the waste is liberated in the form of pure sulphuretted hydrogen gas, the calcium is converted into chloride of calcium, and the magnesium thrown down as magnesia, as represented by the equation:

$$CaS + MgCl_2 + H_2O = CaCl_2 + MgO + H_2S.$$

(calcium sulphide + magnesium chloride + water *yield* calcium chloride, magnesia and sulphuretted hydrogen.) The H_2S so obtained may be treated in two ways for the conversion of the sulphur into a commercial article: namely, (1) by acting on it by sulphur dioxide, whereby pure sulphur is precipitated as a fine yellow powder, which is washed, dried, and sold as sulphur:—

$$2\,H_2S + SO_2 = 3\,S + 2\,H_2O$$

(sulphuretted hydrogen + sulphur dioxide *yield* sulphur and water); (2) by first passing the H_2S through cold water, to remove the steam which is given off with it, and then leading it through a water-sealed cast-iron pipe into a hydraulic-sealed cast-iron chamber, thence into a brick oven where it meets a series of gas-flames and is burned, forming sulphuric acid, as represented by the equation $H_2S + 4\,O = H_2SO_4$. The vitriol thus obtained is said to be almost chemically pure, and after concentration is fit for all purposes for which the best oil of vitriol is used.

Reverting now to our first equation, representing the action of $MgCl_2$ on alkali waste, we showed that besides H_2S there is produced magnesia and calcium chloride. These two valuable products are recovered by an interesting reaction—namely, by passing carbonic acid through the contents of the tanks, whereby the lime is precipitated as carbonate or chalk, and the magnesia converted into the chloride. The liquid is then run into filter-presses; and the chalk obtained on the filter is sold, and the solution of $MgCl_2$ produced is evaporated down to the required specific gravity, namely 1·15, and used over again in the process. The CO_2 used in the latter operation is obtained most economically from the lime kilns of the alkali works, where the manufacture of lime is generally carried on, for the making of caustic soda; it is most advantageously applied under pressure.

42. To Calculate the Contents of Cisterns, or Iron Tanks.

In Note No. 25 we gave rules useful in the case of rectangularly-shaped tanks—that is, where the sides are at right angles to the ends. The following are the rules for finding the contents of cylindrical tanks, or those circular in section, where certain data are given. (1) When the diameter and the depth are given.—If in feet and inches, reduce to inches, then square the number of inches in the diameter of the cistern and multiply the result by ·7854; multiply by the number of inches in the depth of the cistern: the quotient is the number of gallons which the cistern of the given diameter and depth will contain. (2) When the number of gallons which the tank or cistern should contain is given, as also the depth or height of the space in which it can be placed, to find the diameter which should be given to the cistern or tank.—Take the number of the gallons, and multiply it by 277¼; divide the product by the number of inches in depth of the tank, and divide the result by ·7854; then the square root of the quotient will give in inches the required diameter of the tank. (3) When the diameter of the tank or cistern is given, and also the number of gallons which it is required to contain, to find the depth or height which must be given to it.—Take the number of gallons, and multiply this by 277¼; divide the product by the square of the diameter in inches; multiply the result by ·7854, and the quotient will give in inches the depth or height required.

43. To find the Depth in Inches of a Tie Beam* of Fir or Pine—the Length of Span or Bearing in Feet, and the Thickness or Width on Edge being given.

Take the span or bearing of the tie beam in feet, divide it by the cube root of the thickness or width in inches, and multiply the result by 1·47: the quotient is the depth of the tie beam in inches required.

44. Data for Building Calculations and Estimates

(1) *Weight in pounds of a Cubic Foot of different kinds of Timber.*

Teak	46	Walnut	42
English oak	58	Riga fir	47
American oak	42	Memel fir	34
Ash	52	Scotch fir	38
Elm	42	White American spruce	34
Beech	48	Yellow pine	28
Sycamore	38	Pitch pine	41
Poplar	84	Mahogany (Honduras)	40
Chestnut	38	Mahogany (Spanish)	50
Cedar	33		

45. Capacity of Wells.

A cubic foot of water contains, or is equal to 6¼ gallons, or, what is the same thing, each cubic foot of excavation is equal to 6¼ galls. of water. Taking the diameter of a well to be 3 ft., each foot in depth will contain 44 galls.; if of 4 ft. diameter, 78 galls.; 5 ft., 122 galls.; 6 ft., 176 galls.; 7 ft., 239 galls.; 8 ft., 313 galls.; 9 ft., 396 galls.; and 10 ft. in diameter, 489 galls. for each foot in depth.

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* See paper in text entitled "The Carpenter," also "Dictionary of Technical and Scientific Terms."

46. To find the Weight of Round Wrought Iron Rods or Bars, Diameter and Length, both in Inches, being given.

Square the diameter and multiply it by ·7854, and the product by the length in inches; divide the result by the "constant" (see "Dictionary of Technical Terms" under the section of "General Science") 3·6, and the quotient is the weight in pounds.

47. To find the Weight of Plates, Bars, and Balls of Metal.

(*a*) To find the weight of a *plate* of metal.—Find the number of cubic inches in the plate (by multiplying the length, the breadth, and the thickness into one another), and multiply the number found by one or other of the following "constants," according to the metal: Cast iron, ·27; wrought iron, ·28; steel, ·28; copper, ·31; brass, ·30; gun-metal, ·31; zinc, ·26; lead, ·41. Or, for plates of wrought iron, of which there are 3·6 cubic inches to the pound, divide the number of cubic inches in the plate by 3·6. (*b*) To find the weight of *round bars* of metal.—Square the diameter and multiply this by the length of the bar in inches, and the product thus obtained by the following constants: Cast iron, ·206; wrought iron, ·216; steel, ·223; copper, ·253; brass, ·238; zinc, ·204; lead, ·322. To find the weight in one foot of length of a cast-iron bar, square the diameter, divide this by 4, and multiply the quotient by 10. To find the weight of a cast-iron bar where the length is taken in feet, in place of inches as above, square the diameter, multiply this by the length in feet, and the result by 2·48. The "constant" for wrought iron for the same rule is 2·6. (*c*) To find the weight of a *ball* of cast or wrought iron.—Take half the diameter in inches, cube this and divide it by 10; add the result to the amount of the cube of half the diameter of the sphere, and the result will be the weight in pounds.

48. To find the Size of the "Eyes" of Links.

Make the outside diameter of the eye equal to twice the diameter of the pin passed through it; then increase the thickness until the requisite sectional area is obtained.

49. Crushing Weight on Piers of Masonry and Brickwork in relation to their Height or Length.

The height of stone piers should not exceed twelve times the diameter of the base or cornice, or the square of the base. The load they are made to support or carry should not exceed one-tenth of the weight calculated to crush or disintegrate the materials of which these piers are built. The following gives the weight in tons per square foot to produce crushing fracture or disintegration in various building materials:—Aberdeen granite, 500 tons; Peterhead granite, 400; Freestone, 200; Bath, 80; Limestone, Magnesium, 100; Sandstone, 350; Marble, 400; Brickbat, 70: Ordinary or common bricks, 40; Fire-brick, 70; Ordinary brickwork, set in mortar, 20; if set in cement, 30; Masonry set in rubble, 20 tons per square foot.

50. Number of Cubic Feet of various Timbers to make one Ton in Weight.

Teak	48	Riga fir	48
English oak	38	Memel do.	66
American oak	53	Scotch fir	68
Ash	43	American white spruce	66
Elm	53	Yellow pine	80
Beech	45	Pitch pine	54
Larch	72	Walnut	53
Chestnut	59	Cedar	68
Sycamore	59	Mahogany (Honduras)	55
Poplar	66	Mahogany (Spanish)	54

51. Dimensions of Joists for Single Floors.

Single floors (see the series of papers in the text entitled "The Carpenter") constitute the simplest variety of this class of carpentry work in house construction, and consist simply of timber joists laid from wall to wall, a usual distance between the joists being twelve to fourteen inches from centre to centre. The joists in the poorest class of work rest on, and are built into, the walls; in a better class they rest on, and are spiked or nailed to, timber wall plates built into the wall; in still higher class work the joists are notched as well as spiked to the wall plates (see "The Carpenter"). The following are the dimensions—technically termed "scantlings"—of joists for single floors, with spans or bearings—*i.e.*, distances from wall to wall—of different lengths. The span or bearing should never exceed 15 feet for this class of flooring:—Length 6 feet, dimensions 6 inches by 2 inches; 8 feet, 7″ × 2½″; 10 feet, 7½″ × 2½″; 12 feet, 8″ × 2½″; 14 feet, 9″ × 2½″.

52. Specific Gravity of Various Woods.

Oak, ·085; Elm, ·800; Ash, ·845; Beech, ·852; Yew, ·807; Fir, ·657; Lime, ·604; Cedar, ·561; Poplar (common), ·833; ditto (silver), ·520; Apple, ·733; Ironwood, 1·210; Greenheart, 1·200; Ebony, 1·080; Boxwood, 1·050; Cork, 0·240.

53. Relative Values of Timbers or Woods in regard to their Transverse Strength or Resistance to Cross or Breaking Strains.

Taking *English* oak as the *standard, or 100,* we have for (2) American oak, 86; (3) Elm, 82; (4) Ash, 119; (5) Beech, 103; (6) Larch, 103; (7) Sycamore, 81; (8) Chestnut, 89; (9) Cedar, 62; (10) Mahogany (Honduras), 96; (11) Mahogany (Spanish), 67; (12) Walnut, 74; (13) Poplar, 50; (14) Memel fir, 80; (15) Riga fir, 80; (16) Scotch fir, 60; (17) American yellow pine, 99; (18) American white spruce, 86; (19) American pitch pine, 82; (20) Teak, 109.

54. Rule to ascertain the Length of a Beam of Riga Fir to carry a given Weight, the Breadth or Thickness and the Depth being given.*

Square the depth in inches, multiply this by the width or thickness, also in inches, and by 1325 (this "constant" will vary as the timber used varies), divide the product by the weight in pounds; and the square root of the quotient will be the length required of the beam. (See a succeeding note on "The Factor of Safety.")

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* See text paper under the title of "The Carpenter."

THE PRACTICAL NOTE-BOOK
OF
INDUSTRIAL SCIENCE FOR HOME STUDY.

(14) See Note No. 13 on "Fuel and its combustion." The kindling of a mass of coal, which is a gradual process, the heat given out by the part first kindled serving to "set fire to" another portion, and this to a third, depends largely, for the rapidity with which it is carried on, upon the mechanical or physical condition in which the fuel is being used. A lump of coal of some pounds weight is much more difficult to "set fire to" than a piece of an ounce or two in weight, and small pieces of a fraction of an ounce in weight more easily "kindled" still; and uniform condition and size in the pieces of fuel make it more uniform in its combustion, and the heat products more easily to be managed and more readily to be relied on. Watt, the inventor of the modern steam engine, whose scientific precision seemed competent to take in what his great motor would be in all future time, saw the importance of attending to the "condition" of the coal used in raising steam in his boilers, and gave precise instructions how it was to be dealt with. On this important point of condition of fuel we shall have more to say in a succeeding note under this section. A lump of coal, for example, has so many increments of heating power locked up or occluded within it, the mechanical equivalents of which are capable of doing so much work. With a small amount of kindling heat, so to call it, to raise the temperature of the whole mass or lump will obviously take a long time, the difficulty being to get at the parts within the lump; and to get at them a high temperature continued for some time is necessary, the heat breaking or crumbling up the mass into many pieces. The smaller pieces will obviously be more readily "set fire to"; and we can conceive of different qualities of coal having such different breaking up or crumbling properties that the combustion of some, or the getting into the condition of what is called bright burning, will be slower—that is, will require longer time—than others. Some qualities of coal are more readily and easily brought up to the combustion temperature than others—in other words, have a greater facility for entering into combustion with the oxygen of the air, the presence of which in all cases of combustion is assumed as an absolute necessity; a fuel without oxygen being as little a combustible as a paving stone or a brick. But in all cases the element of "condition" of the fuel must be considered as of primary importance. Two distinct qualities of coal, for example—one good, the other indifferent—may be so different in condition that the indifferent fuel, in a condition which aids the combination of oxygen with its constituents under the influence of heat, will kindle more rapidly, and upon the whole be more readily and easily "stoked," than the coal of better quality which is in a condition unfavourable to the combination which produces combustion. Hence, simply by taking advantage of this principle of condition, furnaces are now in daily use in which the veriest refuse of coal gives large supplies of heat. The whole tendency of fuel combustion management of late years has been to carry out the principle of division of the coal; and this so that the combustible constituents shall be presented to the action of the heated oxygen in a way so favourable to the combination of oxygen and fuel constituents which promotes combustion, that the finely divided particles of fuel are flashed into flame with almost the rapidity which gunpowder displays when the heating (lighting) agency is presented to it. The "gas producer furnace," in conjunction with the "regenerative stove or furnace," has thus, through the genius of the late Sir William Siemens, made available all sorts of combustible substances, and given a high value as heat producers to what were perfect nuisances; and by the means of these contrivances it may be truly said that the art of applied heat has completely revolutionised the cast iron and steel making, and given to many processes high temperatures formerly on the large scale wholly unattainable. The gaseous fuel, the result of the Siemens furnace, is simply a change of the condition of the fuel constituents, so dividing large lumps into small pieces, that they are presented in the aeriform condition in which, when exposed to the action of heated oxygen, the combination is so quickly effected that flame of an intense temperature is instantaneously produced.

(15) *Notes on some of the Mechanical or Physical Features of the Air or Ordinary Atmosphere.*—The weight of a cubic foot of air at the average or normal temperature of 62° Fahr. is ·0761 of a lb. The height of the atmosphere being 26119·819 feet, the weight of a column of this height, the base of which is 144 square inches, is 2118·854 lb. avoirdupois, and dividing this by 144 we have 14·711, the weight or pressure upon each square inch of the base of the column. As this is within a little of 15 lb., this latter sum is usually named as what is called the "atmospheric pressure" on each square

inch of surface of all bodies exposed to it. This, however, represents the pressure at the surface of the earth, or at what is technically called the "sea level"; at which point the pressure, as measured by the barometer—the degree of heat being at the time that displayed by ice melting—is 29·922 inches. As this is within a fraction of "30 inches," this is taken as the "standard height" from which all depressions or the reverse in the atmosphere, as shown on the barometric scale, are reckoned. If we measure this normal or ordinary pressure of the atmosphere by that of the elements of water, we find it represented by a column of water 33·831 lb. per square inch, the weight of a cubic foot of water being estimated at 62·5 lb. avoirdupois. We have thus the means of ascertaining the weight of a column of any fluid other than water, and which is of uniform density throughout, which will be sustained or maintained in equilibrium by the atmospheric pressure—this height being to the height of the mercury in the barometer at the time being as the specific gravity of mercury is to the specific gravity of the fluid, the height of the column of which will be balanced by the atmospheric pressure at the time being. Properly speaking, if the air constituting the atmosphere was perfectly dry—that is, absolutely free from moisture—the air pressure, or its gravity or weight, would be represented by a column 32·1824 feet. But the atmosphere is not dry, but varies in its degree of humidity or contained moisture; and it has been ascertained that the relation of the density of air thoroughly saturated with moisture to that which is perfectly dry is expressed in the fraction of which 10,000 is the numerator and 99,749 the denominator. In reference to the pressure of air indicated by columns of water and of mercury, it is worth noting that the specific gravity of water being to mercury as 1 to 13·5, the ranges of variation of any two scales in which water and mercury are employed to measure pressures will be as those numbers inversely, so that a variation in the height of one inch of the mercury column will be equal to or be represented by 13·5 or 13½ inches in the water column.

(16) In Note No. 4 a brief remark is made as to the effect in Portland cement of a mixture of sugar with it, of hastening the "setting." When used with common lime mortar it adds greatly to its cohesive strength; so much so that practical men state that it makes ordinary lime, used in the making of mortar, equal in strength to Portland cement—that is, the cement as used in the ordinary way, without the addition of sugar or saccharine matter. In one experiment, a mortar was made of 1 part common shell lime to 1½ part of sand, with water to each gallon of which is added a pound of an exceedingly coarse cheap sugar used and known in India as *goor* or *jaghery.* Bricks joined with this sweetened mortar, which set in thirteen hours, broke with an average breaking weight at the joint of 6½ lb. Bricks joined with precisely the same mortar, but without the saccharine matter, showed the average breaking weight at the joints of 4½ lb., giving an increase of strength in the sweetened mortar of over 30 per cent., or one-third. Dr. S. Crompton, to whom the scientific world is indebted for much interesting information on this subject, points out also that frost has no deleterious influence on mortar sweetened with sugar. This alone would give great value to the method; for those of our readers who are concerned in building operations know, many of them to their painful cost, how frosty weather puts a stop to all work which is to be honestly well done. In another note we shall have one or two remarks on the scientific aspect of this method of dealing with Portland cement and with ordinary limes or mortars—a method which it appears from pretty good evidence was practised by our ancestors in this country, has been practised from time immemorial in certain parts of India, and going further back into history, practised, there is good reason to believe, by the Romans, if not by a people who flourished earlier still—namely, the Egyptians.

(17) Accidents arising through the use of illuminant fluids, known generally as the paraffin oils, are now unfortunately of common occurrence. These arise through the great ease with which some of the oils flash into flame at exceedingly low temperatures, and the extreme difficulty there is of extinguishing the flame when once it is created. All of what are called by the common name of the paraffin oils require to be dealt with with the greatest care. The necessity for this care is shown by the number of the most painful accidents taking place continuously, and may be explained and enforced by many facts. In our notes on "Fuel and its Combustion" (see Note No. 13 and others) the reader will find explained what combustion is, and how an important element or factor in the process is the oxygen present in the ordinary atmosphere or air, but which must be heated up to a certain temperature —varying with the kind of combustible or fuel— before the oxygen can enter into combination with the combustible constituents of the fuel, and flash into flame, and create what is called artificial heat. Now, paraffin oil is a fuel, but a liquid one, just as ordinary lighting gas is a gaseous fuel. And in the case of both of these fuels the temperature at which the air which provides the oxygen necessary to create and promote combustion, compared with that required for solid and dense fuels, such as coal, is very low. Hence the danger in dealing with paraffin.

FORM AND COLOU

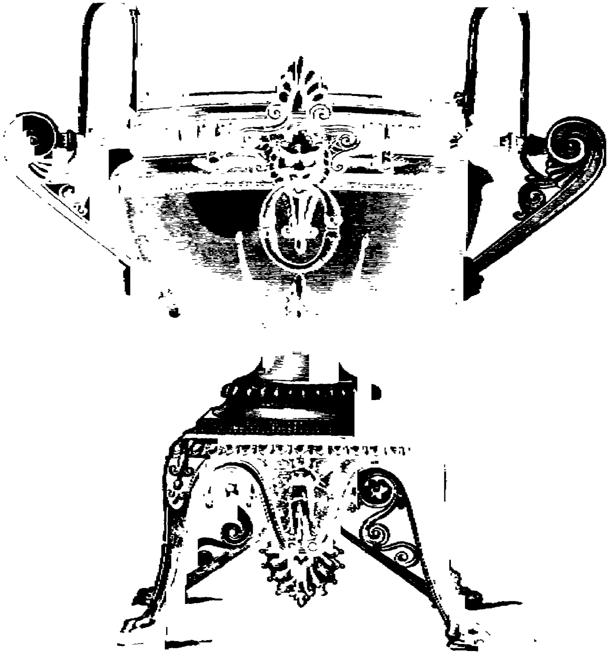


Fig. 1.

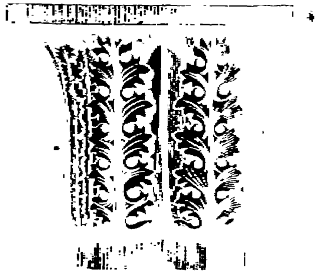


Fig. 2.

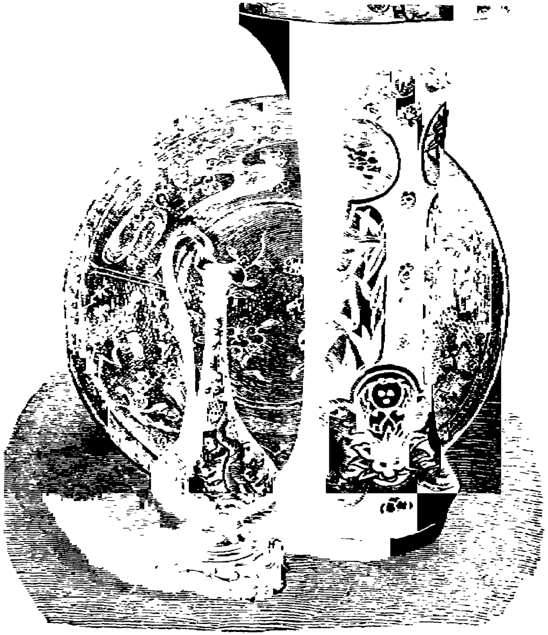


Fig. 3.

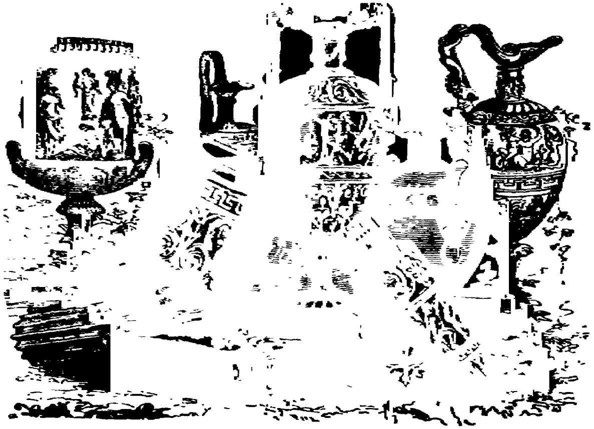
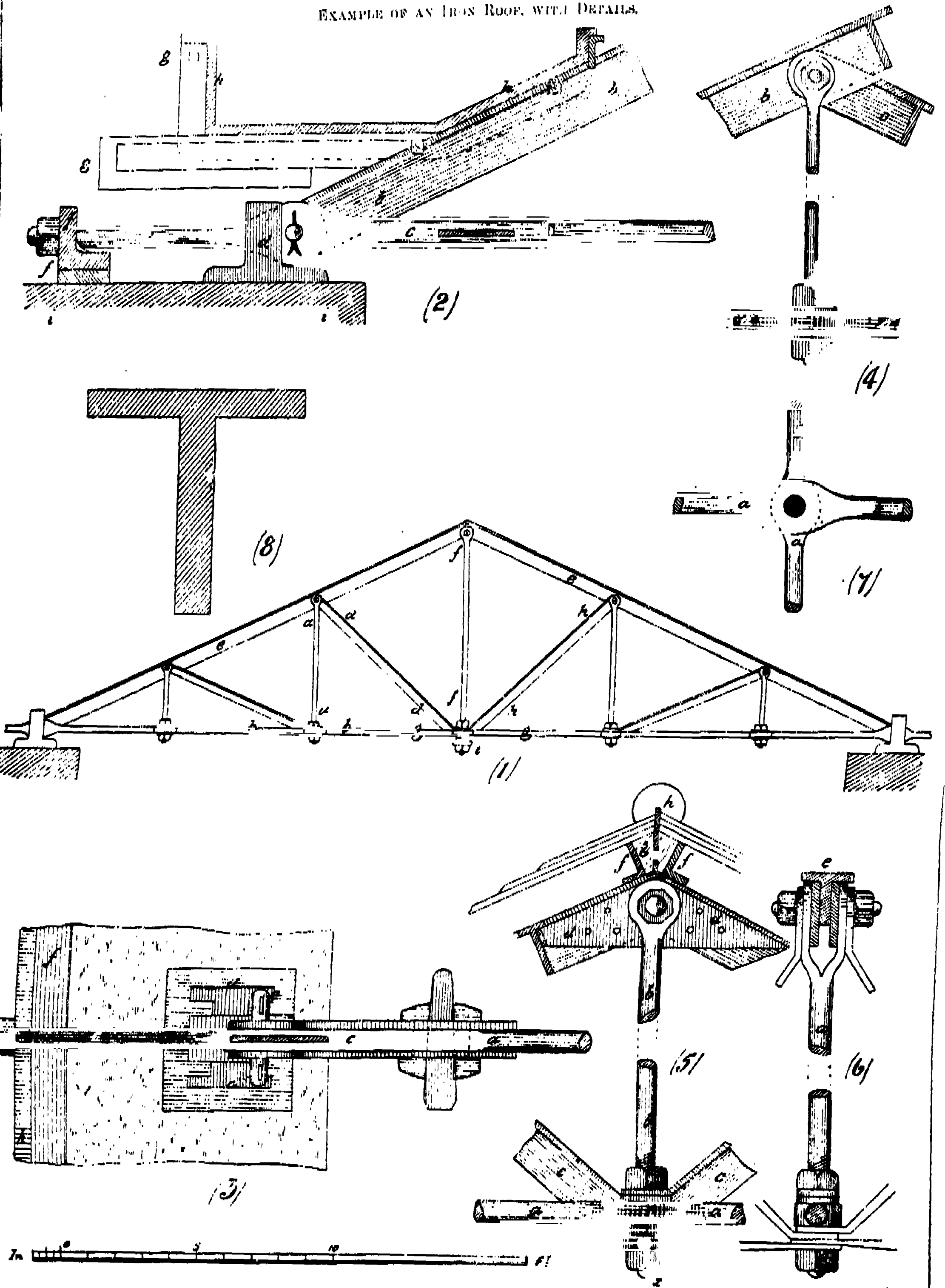


Fig. 4.

TIMBER AND IRON FRAMEWORK *(see Text).*

Example of an Iron Roof, with Details.



THE ORNAMENTAL DRAUGHTSMAN *(see Text).*

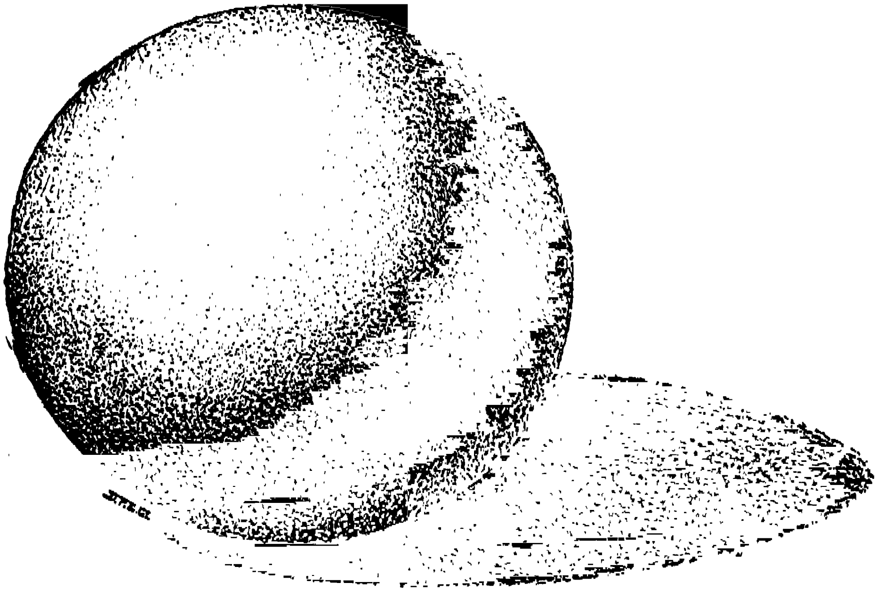


FIG. 1.

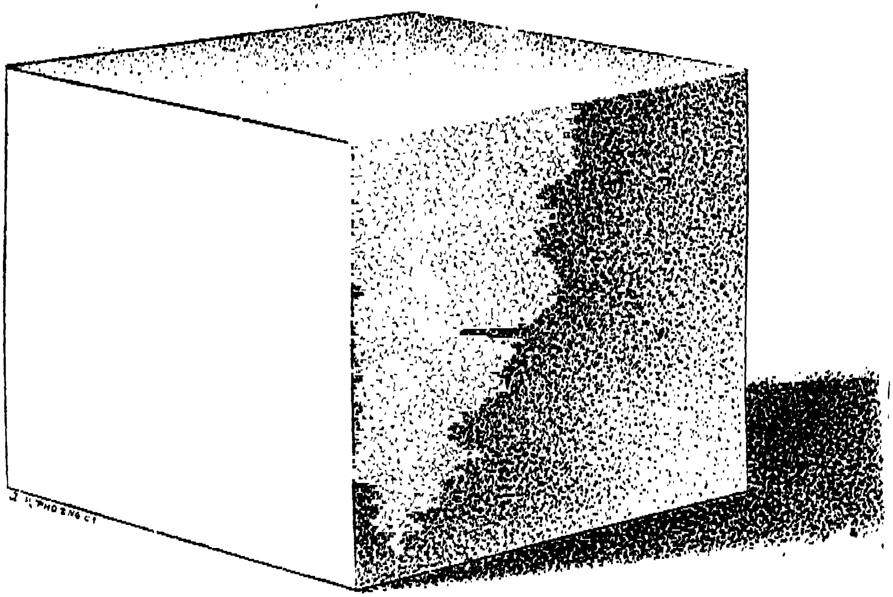


FIG. 2.

FIG. 3.

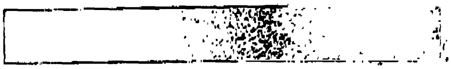


FIG. 4.

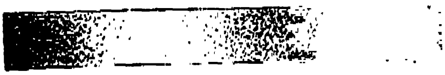


FIG. 5.

THE STEAM ENGINE USER AND MANAGER *(see Text).*

DETAILS OF HIGH-PRESSURE STEAM ENGINE.

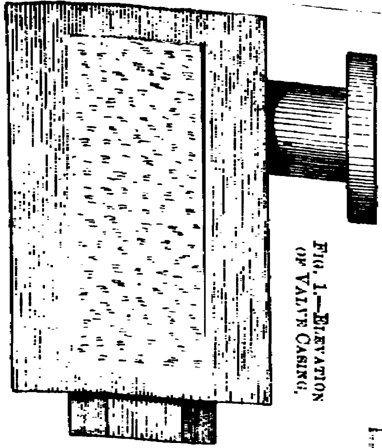


Fig. 1.—Elevation of Valve Casing.

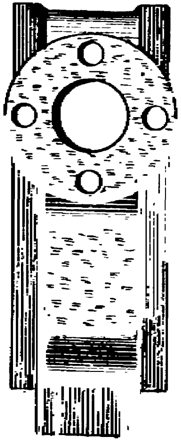


Fig. 2.—Elevation of Valve Casing.

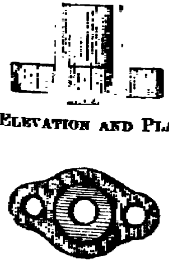

Figs. 3 and 4.—Elevation and Plan of Gland.

Fig. 5

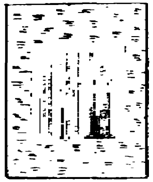
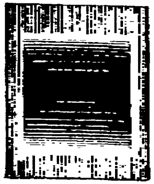

Inside Plan of Valve.

Fig. 6.


Top Plan of Slide Valve.

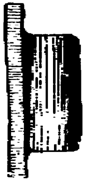


Fig. 7.—Elevation of Slide Valve.

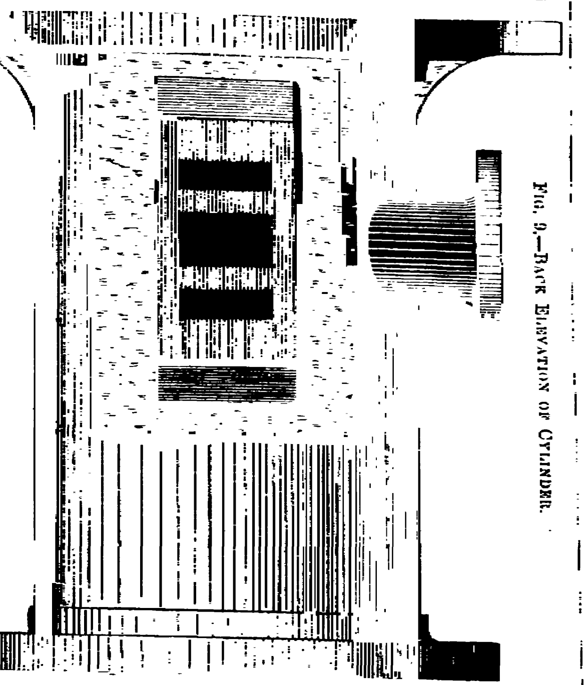


Fig. 9.—Back Elevation of Cylinder.

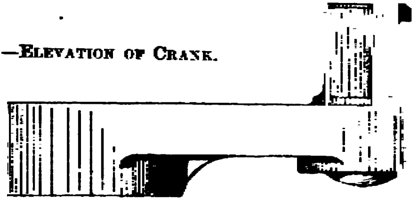


Fig. 10.—Elevation of Crank.

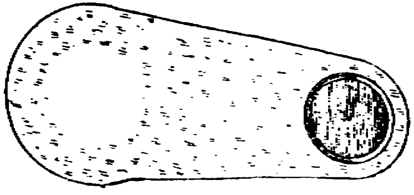


Fig. 8.—Plan of Crank.

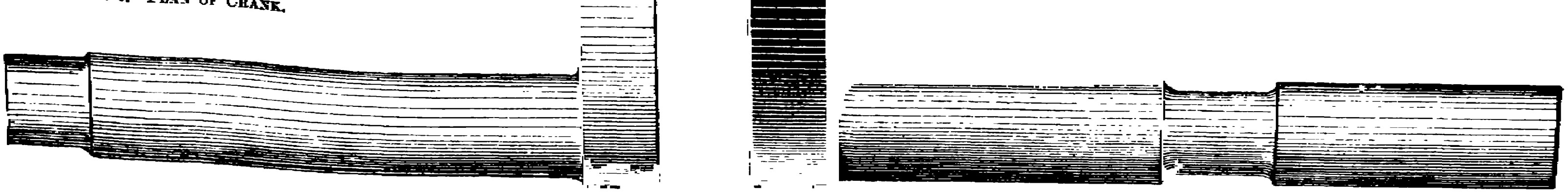


Fig. 11.—El v tion of Cr h ft

THE ORNAMENTAL WORKER IN METALS *(see Text).*

THE ELEMENTS OF ORNAMENTAL IRON-WORK.

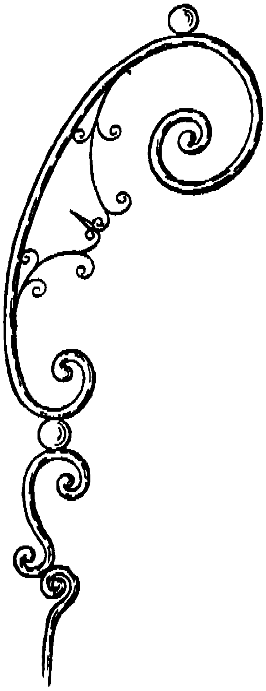


FIG. 1.

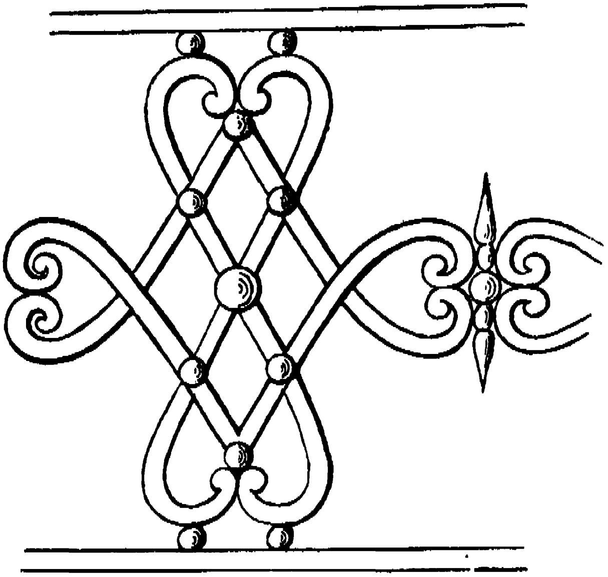


FIG. 2.

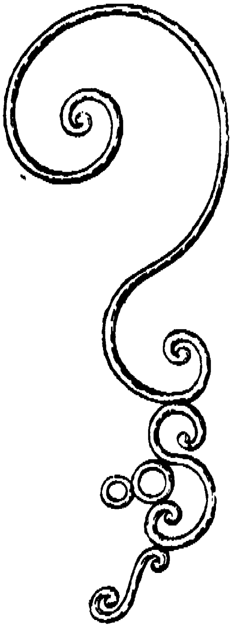


FIG. 3.

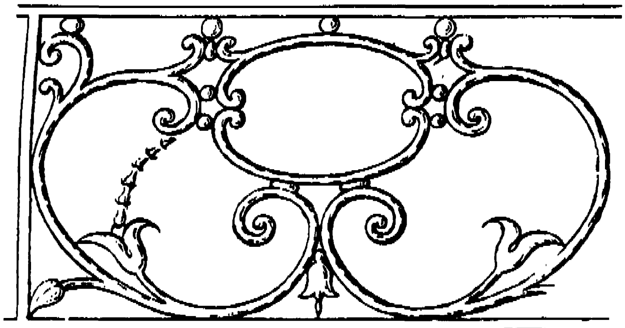


FIG. 4.

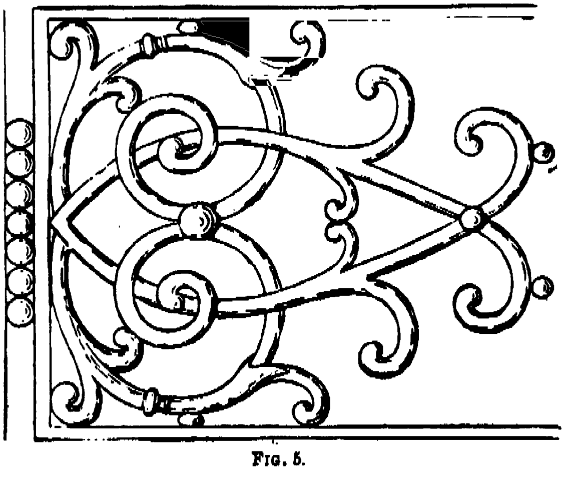


FIG. 5.

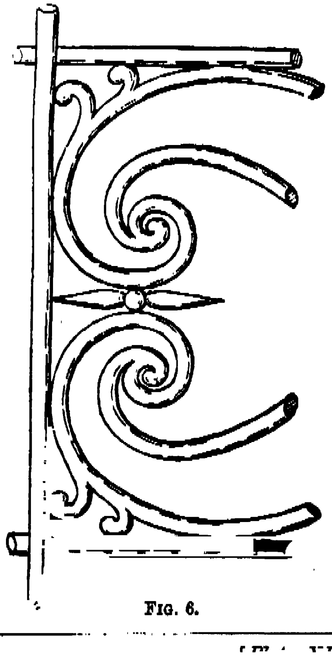
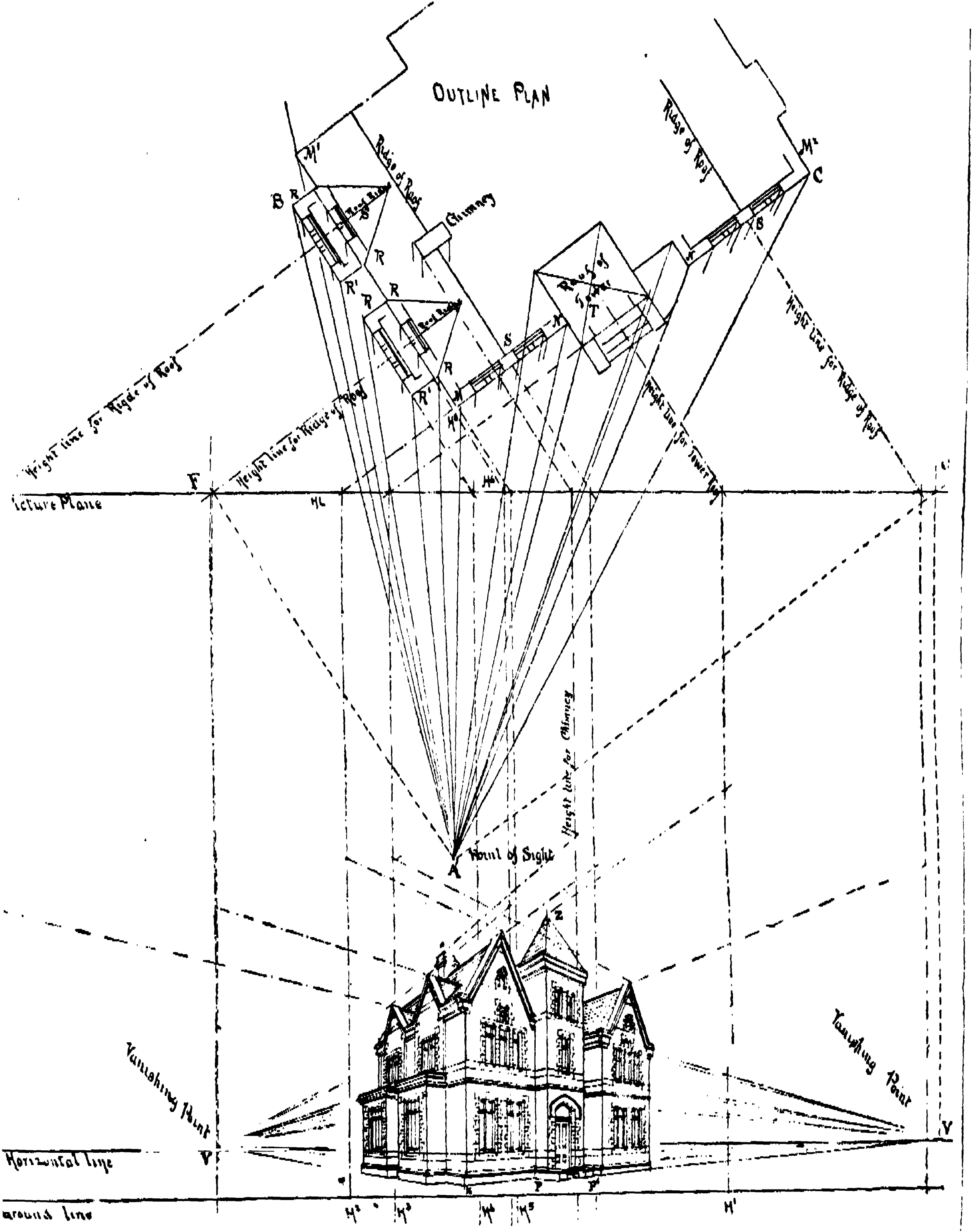


FIG. 6.

PLATE III.


Outline Plan
Ridge of Roof
Ridge of Roof
Chimney
B
R
Roof Ridge
S
R
R'
R
R
Roof Ridge
R
R'
M¹
M²
C
Roof of Tower
T
S
S
N
N
N
H⁶
Height line for Ridge of Roof
Height line for Ridge of Roof
Height line for Tower Roof
Height line for Ridge of Roof
F
Picture Plane
HL
Point of Sight
A
Height line for Chimney
Z
Vanishing Point
Vanishing Point
V
V
Horizontal line
Ground line
H²
H³
H⁴
H⁵
H¹
P
P

Elements of Ornamental Work in Stone and Terra Cotta.

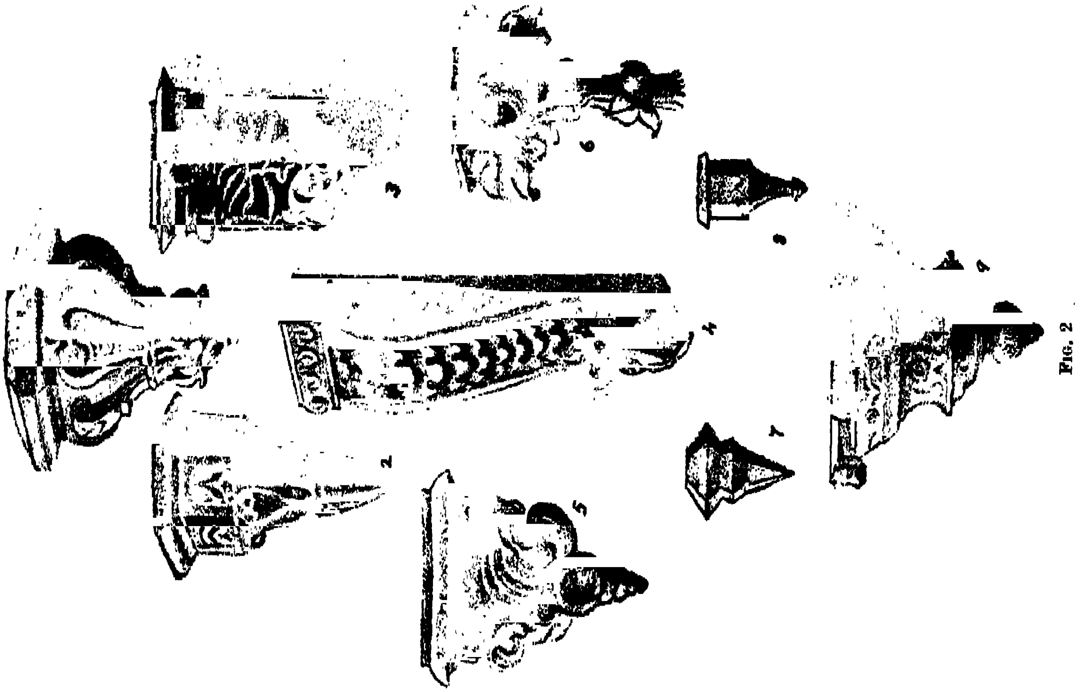


Fig. 2

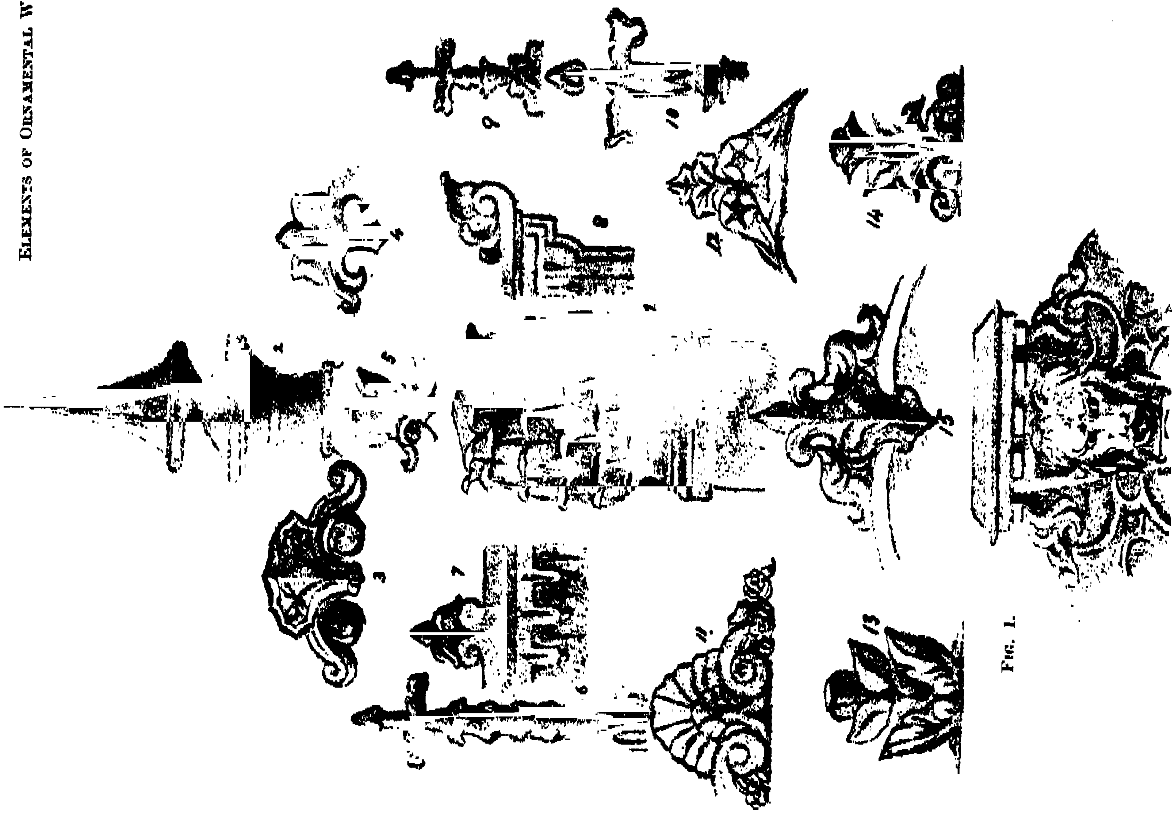


Fig. 1.

TECHNICAL EDUCATION

IN RELATION TO

THE PRESENT CONDITION OF OUR INDUSTRIAL WORK.

The Position of Masters or Employers in Relation to Industrial Education.—A Knowledge of its Principles and Subjects of Vital Importance to them.

With regard to those who have the prospect of becoming masters, employers of industrial labour, it will perhaps be matter of surprise to some to be told that much of the future of the industrial trade of our country is dependent upon the way in which our masters of the future are trained. But too many evidences exist around us to show that the special training of those youths who are likely, from their position as the sons or relations of those who own large concerns, to be masters of the future, has never been systematically formulated. But there is amongst all thoughtful, practical men almost, if not quite, a universal consensus of opinion to the effect that the special training of employers will be one of the most effective factors in the solution of the great question how to retain, if we cannot increase, our national trade as industrial workers. Much of what we have said in relation to the manager applies to the master; but the master has duties and responsibilities which do not fall upon the manager. In finding out new markets, and in the way of working these, there lies an amount of work in special training which few have thought of, but which are simply of vital importance to us as a people. Our foreign rivals, our great competitors, afford themselves perhaps the best examples which it would be wise in us to follow. Take the Germans, perhaps the keenest and ablest of these: they are not indifferent to the finding out of new markets, however far afield they have to go for them; and their skill in initiating a method or methods of working them to the best advantage is as distinguished for common-sense ability as the way they go about the carrying of these methods out. Their facility—at all events their industry—in acquiring a knowledge of languages other than their own, enables them to open up communication with the new peoples they wish to trade with, and they make use of the knowledge in the most practically common-sense ways possible to them. However prejudiced they may be with regard to the peoples they have opened up trade relations with—and German national prejudices are not a whit less keenly developed than our own—they take the greatest pains, by mixing with all classes familiarly, to learn their wants in the way of goods; and when they know them they are not slow in making the articles. Their education at home is specially designed and carefully carried out with a direct view to enable them to be the best pioneers in opening up new markets, and in ingratiating themselves with their people so that they quickly become their customers. In brief, they make their trading and their commercial system a science, and adapt their home educational system to the teaching of this, so that they send out to all parts of the world merchants and travellers who, in too many instances, beat our men out of, or largely out of, the market, who have not the same adaptability to new circumstances, and have not as a rule that cosmopolitan knowledge of men and manners, customs and language which their competitors have. And this, so far from being foreign to our subject, bears in the closest possible way upon it, and goes to show the necessity for classes who have hitherto been considered as independent of *industrial education* henceforth becoming clearly and intelligently acquainted with all its branches. Hence masters, or those who are likely to be such in the not remote future, may find something in the pages of the INDUSTRIAL SELF-INSTRUCTOR FOR HOME STUDY which cannot fail to be of the greatest practical value to them.

The Success of a System of Industrial Education Strictly Dependent upon the Maintenance of a Certain Definite and Dual Relationship.

As in the actual carrying out of industrial work in the factory or the workshop, pecuniary success, and assuredly pleasure in the doing of it, as well as a steady continuance of its remunerative labour, are largely dependent upon the way in which the dual relationship of employers and employed is arranged and maintained, so also is it true that the *individual* system of industrial *education* is for its assured success largely dependent upon the maintenance of a dual relationship between the subjects of *Home Study*, which are purely technical or scientific, and which are gained by the exercise of the intellect only,—between these and certain habits of study and action bearing upon the doing of the actual work, thus embracing the work of study and that done in the factory or the shop. And we should be ill fulfilling the grave responsibilities connected with the duty which devolves upon us as publishers and conductors of so important a work as ours if we did not point out in the plainest and most distinct manner that, unless this dual relationship just now referred to be carried out with strict integrity and honesty of determined will and purpose or plan, the golden dream which so many indulge in as to what *industrial education* is to do for the nation will not be realised. If certain habits in relation to study and to actual work do not exist, or are not exercised, all the technical or scientific knowledge of the work will possess little practical money-making value. Some of those habits applicable alike to study and work will be named with greater or less detail in the paper in the text of this work entitled "The Workman as a Technical Student, What to Study and How to Study," and exemplified here and there in appropriate paragraphs in more than one of the practical papers in the body of the work. There are others, however, which, of great importance, demand some notice here at our hands. For such habits were amongst the most powerful of the influences which built up, so to say, the solid structure of English reputation for turning out the best work in the best possible way both as regards efficiency and economy of production. And if what has done so much for us in the past is not deemed likely to do something valuable for us in the future, all the scientific and technical knowledge which may be imparted to our workers will be but of little service in enabling us to meet the stern competition which faces us in all the markets we once wholly called our own. Nor is the fact unworthy of the most serious consideration as constituting a factor in all our calculations or questions regarding technical education, and what it is supposed to be able to do for us, which must be taken into account if we are wise,—that in the opinion of eminently practical men, of large and wide experience in industrial work, much of the trade we have of late years lost has been lost, virtually handed over to our foreign competitors, through neglect of or indifference to those very habits which, as we have said, made at one time that high reputation of our country to which we have referred. No question, therefore, can be more serious than this. And it will rest with ourselves whether that reputation shall be won back where we have lost it, and retained where we still possess it. And if we decide in the affirmative, the cultivation of those habits must form a much more definite and decided place in our national system of *industrial education* whenever it is, if ever it be established, than, to judge from what they have said, the loudest talkers on the subject seem to have thought of. The fact must never be lost if we are really to approach to, or obtain the realisation of, the hopes which the advocates of what they call technical education hold out to us: that all the marvellous work—for it is neither more nor less than this—which our engineers and machinists, our iron makers, our practical chemists have done in the years which are past, the building up of that grand reputation as makers to which we have referred, was done *not* with the aid of, but in spite of, the almost utter want of all those facilities for education which form part of what is now called technical education. And all this was done, moreover, not with the help, but in the almost absolute default of the many machine tools and workshop appliances which engineers, machinists, and other industrial workers have now at their command.

Brief Considerations in Regard to the Relation of Industrial Education to the Actual Industrial Work of the Home Student.

The habits in connection with the doing of work, to which pointed reference was made in the preceding paragraph, will be found detailed in the paper in the text, "The Workman as a Technical Student, How to Study and What to Study"; in some of the paragraphs in "The Industrial Students' Note Book," which form part of this work; and incidentally, but in close connection with the actual work done, in several of the practical papers in the text, such as "The General Machinist," "The Joiner," "The Carpenter," "The Bricklayer," "The Stone Mason," and in the earlier paragraphs of "The Student's Introduction to Mechanics." Good service to the home student will be done if the brief space still remaining of this paper is devoted to one or two considerations of great importance to his work and study. The latter must be always carried on with the distinct understanding that it leads up to his actual work in the factory or workshop, and that the results of both —study and work—are absolutely dependent upon himself. Education is, to paraphrase the words of a great man, first, the education we get from our teachers; second, that obtained from ourselves. And of the two the last is the more important in its influences. Men who have "made their mark" in industrial work of any kind will confirm without hesitation the truth of this statement. In the course of his *self-instruction* let him study closely the way in which work is actually *done*, as well as the principles upon which the work is based. And from the moment he enters upon his apprenticeship he must begin that course of close observation and intelligent comprehension of all the handicraft details of his workshop or factory—that self-education in actual work which may be said never to end, as the wisest amongst us knows that he never ceases to learn. Here, although he may have his attention directed by others to much that is worth knowing, everything depends upon himself. No one can take his place so effectively as a teacher but himself. And granting that he has what we deem essential (for without it no progress will be made)—namely, a liking or a taste for the practical calling he has chosen to work at so that working he may live—he may be largely gifted with that instinctive feeling or intuitive notion that he can do something worth doing: he knows that he can do it. This faculty should be carefully cultivated, even though he has it developed in the marked degree which some have. And many more, we may remark, have it than is generally supposed; and it is to them simply invaluable, for they can tell at once by "how the work looks" whether it is well or ill done. Where the feeling is only partially existent, or but feebly developed, a vast deal can be done by patient and careful training. And in this again the best help is self-help. None the less fortunate, however, will he be if he meets with some clever friend who will guide him in this training, or a teacher of some technical school who himself has the ability to perceive what a powerful factor is this intuitive knowledge of what *is* good work and how it should be done—a recognition, be it noted, but too rare, we fear, in technical schools, where the tendency to keep to theoretical and "learned" teaching is all too great. In everything the self-instructing industrial student does he must be honest with himself, to the end that it is done thoroughly, as well as it can be done. If he "takes a pride" in his work, he will be sure to be "thorough" in all he does. It may well be an open question in how far our trade is lessened and competition increased by a decay of this "taking a pride in one's work" on the part of so many of our workmen. This was the secret of the grand work done in days gone by. Another important point in the self or home education of the industrial student, and one which may be said to flow out of or to be supplementary to the last consideration, is the absolute accuracy with which every detail of his work is to be done, so far as this is attainable. How much of this is dependent upon the training of the eye to distinguish forms and appreciate distances and dimensions, let the ablest and most skilful of our mechanics say. To attain this facility to do accurate work it is, therefore, not merely necessary to possess manipulative skill to do the work, to make required forms, but to be able to know whether such forms are in themselves accurate; and this can only be done by the teaching of long-continued comparative observation, for it is only in so far as we can tell that differences exist between one body or form and another that accuracy is attainable. And how much, even now that we have abundance of machine tools of precision capable of giving us surfaces and shapes or forms in an almost endless variety of ways, is dependent upon the work which the eye and the hand of man can do, so that if we require the utmost accuracy attainable, we shall have to bring in to the aid of our finished machine tools the aid of the skilled handicraftsman! From these and other considerations much might be named here did space permit. And it will be observed that there is a field as wide as it is important in which the home student of industrial education can exercise those gifts with which he is endowed towards his improvement in the peculiar branch or branches of study in which he is specially interested, and still further enhance the value of those gifts by their careful cultivation. A field also not less wide and important in its issues, in which he can exercise those habits, alike of work and of study, without which all the technical knowledge which he can obtain by home study or time given to him through the medium of teachers outside the home will be of little value in improving the condition and in brightening the prospects of our national industrial work. We have shown that, as in this great national work a combination of help of individual exertion and abilities is necessary, one class not being in any sense independent of the other; so in like manner, in regard to the student, a combination of habits and of effects is necessary in order to obtain all the advantages which flow from a careful or systematic, and an honest, earnest arrangement of industrial self-education at home. What those combinations in both directions are, and the points which constitute their chief value, we have in this paper briefly glanced at: their function and further consideration will be met with in the papers in the text to which reference has been made.

THE STONE MASON AS A TECHNICAL WORKER.

THE PRINCIPLES AND PRACTICE OF, AND THE MATERIALS HE EMPLOYS IN, HIS WORK.

CHAPTER IV.

Bond in Coursed Rubble-work Walls.

N the last figure (23) in preceding chapter we illustrated what is termed a "through" or "through stone." This figure, taken in conjunction with next figure here given (24), illustrate the way in which bond is obtained in "coursed rubble work"

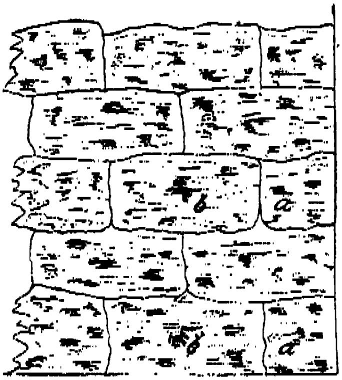


Fig. 24.

by setting the blocks as "headers" and "stretchers," the "header" *a a*, in fig. 23, being in this case a "through." The sketch in fig. 24 shows an elevation, and how the blocks all "break joint." Fig. 7 (*ante*, p. 24) illustrates the cross section of a wall in coursed rubble work in which no "throughs" are employed—but only "longs and shorts," the interior of the wall being made of rough or random or small-sized blocks of various dimensions, as shown. Fig. 9 illustrates another section of a wall of coursed rubble work in which no "throughs" are employed, but only "longs and shorts," forming in the elevation "headers" and "stretchers." In this illustration the interior or

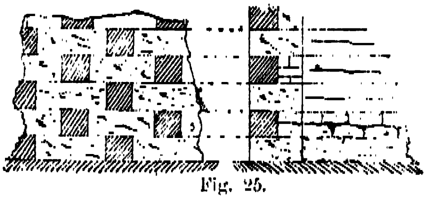


Fig. 25.

"heart" of the wall is made up with "rough or random rubble" well grouted with mortar. Fig. 8 shows in elevation how "breaking joint" is obtained work partially employed. Fig. 18 (p. 121) illustrates in coursed rubble in the centre of the wall, the blocks being of varied dimensions, and rough or random, the disposition or placement of blocks in polished or rubbed or tool-jointed work, in elevation showing how the blocks break joints; the corresponding vertical joints in the alternative courses all run, it will be observed, in the same line. Fig. 25 is intended to illustrate more closely the relation between "headers" and "stretchers," the "headers" being shown as in section, with cross lines, or "hatched," as the technical term in wood engraving is.

Position of Bonding Stones—"Longs" and "Shorts" at the Corners of Buildings "Quoins."

The pupil will perceive that, as illustrated in fig. 26, the blocks which appear in the elevation to the left as "headers," in the elevation to the right at the corner, or as it is technically called "the return" of the wall, appear as "stretchers." On the contrary, the blocks which appear as "stretchers" in the section appear as "headers" in the elevation, and *vice versâ*. A little thought will enable the pupil to understand how this result is a necessity arising

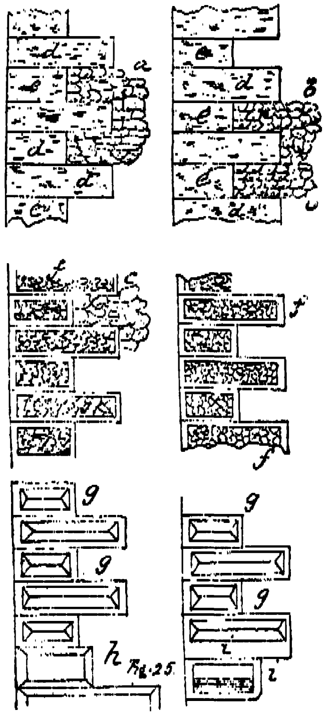


Fig. 26.

from the disposition of the blocks of one face of a wall as "longs" and "shorts," or "headers" and "stretchers," the breadth of a block in the one face acting as a "stretcher," obviously showing as the end of a "header" in the other face.

This disposition at the corner of a wall is the invariable result of employing "stretchers and headers" in its construction. And the stones at this part of the "return" of a wall are technically called "quoins," various forms of which are illustrated in fig. 27. The term is clearly a corruption, or rather the simple substitution of a "qu" for a "c," in the spelling of the French word *coin*—a corner. (See the term "Quoin" in the "Cyclopædic Dictionary of Technical and Trade Terms.") Shakespeare speaks *of the "coigne of vantage," meaning thereby that one who stands at or possesses the corner of a building or wood commands or can sweep with his artillery the two sides of it.* "Quoins" are in civil architecture, public buildings, and domestic structures, generally so arranged as to form a distinguishing or ornamental feature in the design. If the body or bulk of a wall be constructed in coursed rubble work as at *a* in fig. 27, or in rough or random work at *b*, or in irregular rubble where the stones are purposely dressed to form odd and various shapes, as at *c*, the quoin stones are usually of polished or rubbed ashlar blocks; or if only hammer-dressed, are more carefully tooled than usual. The object in both cases is to give a distinctive because different character to the quoin blocks, to distinguish them from the rubble work of the body of the walls. This their mere size would also do. When the whole of the wall is thus formed of rubble work one or other of the ways, as at *a b c*, the quoins are left plain generally in surface—*i.e.* not rusticated, etc.—and the joints also are plain, as at *d d*, *e e e*. When the body of the wall generally is built in polished ashlar work, the "quoin" stone surfaces are either rusticated, as at *f f*, with tooled margins rowed or smooth (see fig. 14), or the surfaces are finished as at *g g*, after the manner illustrated in fig. 16. And in place of having the joints plain, as in those methods now described, they are "wrought"—to use the technical term for worked or tooled—after the manner illustrated in fig. 16 (see also *i*)—this disposition being shown at *h h*. The pupil will, in these sketches of "quoins," see another illustration of the disposition of "headers and stretchers" at the return or corner of a wall: the long quoin in the sketch, on the one face of the wall to the left, appearing as a short quoin stone in the sketch to the right, which is the other

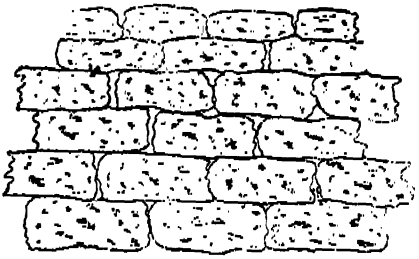


Fig. 27.

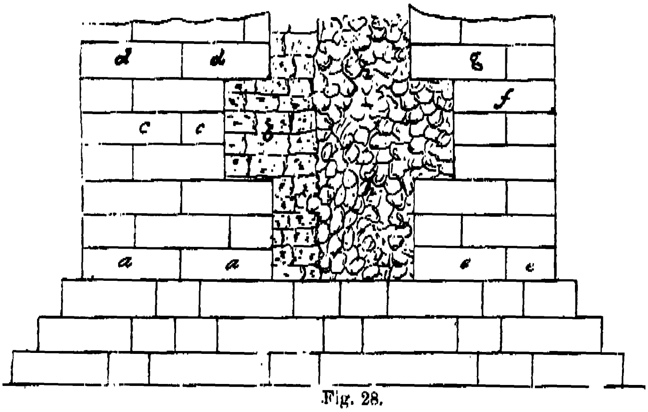


Fig. 28.

"Block in Course" Walling.

We have still, in addition to the varieties of disposition of stones in the formation of walls, to illustrate a modification of coursed rubble work, or what in reality is a compromise, so to call it, between coursed rubble work and ashlar work. This is illustrated in fig. 27, and is known as "block in course." The courses are not all of equal thickness or depth throughout, but generally the thickest stones are used at the lower courses, the thinner at the upper courses, the courses often gradually merging into ordinary coursed rubble work. The depth or thickness of the thickest stones is, as a rule, less than the average or minimum depth or thickness of ashlar blocks.

Stone combined with Brick in Walling.

Stonework is often combined with brickwork; the brickwork generally forms the outer facing of the wall, as at *a a*, *e e*, *c c*, *d d*, fig. 28, the interior or heart of the wall being filled with random rubble work, or, if desired, with coursed rubble work—generally rough rubble is employed. Combined brick and stone work is, however, the reverse of this arrangement; the outer facings being built in coursed rubble, as at *a a*, fig. 29, the heart of the wall being filled in with brickwork, as *b b*. In all combinations of different kinds of work or materials, such as brick with rubble work, as in fig. 29, or with ashlar and rubble work—of which latter, by supposing the outsides or faces to be in ashlar or straight-outlined blocks in place of rough, as shown, fig. 7 may be taken as an illustration—the greatest care should be taken with the "bonding" of the different materials, so as to prevent rupture of the courses by uneven settlement of the walls, or by irregular pressure on them.

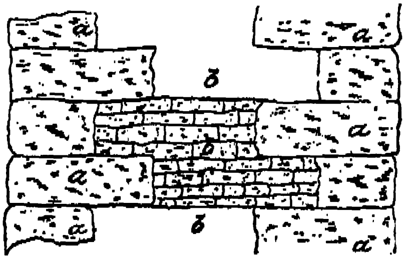


Fig. 29.

THE GEOMETRICAL DRAUGHTSMAN.

His Work in the Construction of the Figures and Problems of Plane Geometry, Useful in Technical Work.

CHAPTER I.

Introductory.

Geometry has been called a universal science. It is difficult to name the technical work or art in which its principles are not exemplified and the practice of its branches not required to a greater or less extent. Its lines, forms, or figures, are met with everywhere, and in its problems are involved principles on which some of the most important work of man is dependent. In the arts of construction, of whatever kind, to the work of the general artificer its help is indispensable. In the varied forms or bodies which are made or constructed by the manual skill of the workmen, or wrought into an endless diversity of shapes or configurations by powerful or delicate machinery, its lines and figures are displayed; and many who are ignorant of its principles are nevertheless in their daily labour working out the problems of geometry, on methods or systems prepared for them by those who know those principles well. Even in branches of man's work known generally as artistic, and with which in popular estimation geometry has little concern, its principles are more or less developed in their practice; and the painter of a landscape or of a figure subject, or the designer of decorative ornament, does part of his work in accordance with rules which are based on purely geometrical problems.

Wide Range of Practical Technical Work, in which the Principles of Geometry are Exemplified.

But if it be somewhat difficult to trace the connection of the science with some departments of the labours of man—for example, as those just named—there is a wide range of work in which this connection is so obvious that it is apparent even to the most careless of observers. This wide range of work embraces all the branches of construction, of whatever kind, be it that concerned in the various branches of building, of machinery, or of architecture and engineering; as well as in a great number of the operations of what may be called general work. The bricklayer and the mason cannot erect a stable wall, or set out the directions which it assumes in relation to another, or to other walls, without availing himself of methods which are purely and essentially geometrical in their principle. The same is the case with the carpenter, the joiner, the cabinet maker, the machinist,—who cannot cut out or form the various pieces or members of their work, or put them together to form the complete construction, without exemplifying at every step of their progress some one geometrical problem or another. The metal worker, the coppersmith, the tinsmith or brazier, the boiler maker, cannot cut out on the flat the pieces of metal which, when bent or curved or placed together, assume the forms or bodies which they desire to make, without availing themselves of methods of "setting out" their work which are based upon some of the highest, as they are the most interesting, of geometrical problems. Nor less can the ornamental or pattern designer, the landscape gardener or the like callings, which are more or less artistic, set out their intricate lines and figures without the aid of geometry. Of all this, examples numerous and striking are met with in everyday life, and will be more or less fully illustrated in one or other of the papers in this work, under such heads as "The Carpenter," "The Joiner," "The Bricklayer," "The Stone Mason," "The Cabinet Maker," "The General Machinist," "The Young Architect and Engineer," and specially in such papers as "The Building and Machine Draughtsman," "The Ornamental Draughtsman," and in those papers taking up the various branches of the general subject of "Form and Colour in Industrial Decoration," such as Mouldings, Ornamental Carpentry Work, Metal Work and Masonry.

The Geometrical Problems carried out in Technical Work too frequently done by "the Rule of Thumb" without any Knowledge of the Science.

But, wide as we thus see is the application of geometrical problems to the everyday work of the constructor, the artificer, and the designer, it is nevertheless true that in a very large number of instances these problems are worked out simply by what is called the "rule of thumb." The methods have, in the workshop, been handed down from one generation to another, and workman after workman does what has been done before him in the most absolute ignorance of the fact that he is constructing figures or forming bodies by methods which are based on, or form complete problems in geometry. Such workmen—and they are but all too numerous—do their work, but they have no conception of the "reason why" they do it, and why it must be done in that particular way if it be done at all. Hence it comes about, as a natural consequence of this state of matters, that if any work is to be set out, figures formed, or bodies made, which are new to them, involving new geometrical constructions, they are, to use a graphic phrase, "quite at sea," and know not how to proceed.

Practical Value to the Technical Workman of a Knowledge of Geometry.—Scope and Scheme of the Present Paper.

It is scarcely necessary to say that if to the manual dexterity with which they draw old established figures, or form the well-known bodies the methods of doing which have been handed down from one set of workmen to the other by the rule of thumb, they could add a knowledge of the principles upon which the work was based, that work would be all the better, because more intelligently done. And with increase of intelligence as to the nature of his work will come an increase of interest in the doing of it, and the doing of it better will be the almost inevitable result. It is the union of practice with theory which gives to practice its highest value, its greatest help to rapid progress in improvement. On this point the reader may read with profit some remarks which he will find in the early paragraphs of the paper in this work entitled "The Workman as a Technical Student—How to Study, and What to Study." It is quite unnecessary, after what has been said, and in view of what the reader will have for himself decided as the right thing to be done, to offer further remarks on the value to the workman of a systematic knowledge of the science of geometry. Not merely as aiding him greatly in doing the work he has been accustomed to do better, because no longer dependent upon the weak support of custom, habit, or rule of thumb, but as opening up to him a range of problems by which he will be able to undertake a wider and a higher class of work, and thus raise his position as a workman, will this systematic study of geometry be of great value to him. In commencing, then, this study, it is only necessary to state that the technical requirements or wants of the workman will be closely looked after in the arrangement of the paper under our present title. We shall have of necessity to go over the same ground which so many have traversed before us, and this inasmuch as in a fixed science like that of geometry, its constructions and problems are the same in all cases. But although we have the same ground to go over, we shall endeavour to traverse its surface in a way as agreeable and as practically suggestive as possible, and may perhaps be fortunate enough to present old objects under a new aspect, or suggest new ways in which they may be applied in practice. The paper is based as a rule upon two exceedingly able and well arranged Continental works, from which many of the diagrams illustrating construction have been taken, together with many remarks bearing upon them. But, as already hinted at, there will also be much given in the course of the papers which is new, or at least which will have new application. Taking the paper as a whole, we trust it will be found of truly practical service to those of our readers who are ambitious to make that progress in a thorough knowledge of their work which alone can insure and will deserve success.

Origin of the Science of Geometry.

If the reader will turn to the Dissertation preceding the "Cyclopædic Dictionary of Technical and Trade Terms," forming part of this work, he will see in classical words the linguistic root or derivation of the word "Geometry." The science was in its earliest developments applied, doubtless, to the marking off of those lines on the surface of the ground which served to distinguish the property or the plot of land cultivated by one man from that possessed or cultivated by another. And this was done in the first instance, as may reasonably be conjectured, not so much for the purpose of preventing disputes between man and man, or putting a stop to encroachments of those ambitious to possess the land of their near and quieter neighbours, as by the government for the purposes of taxation. In Egypt, where the science of geometry first took rise, the whole land bordering on the banks of the Nile, the only source of fertility in that rainless land, was plotted off into a vast number of allotments; and as each cultivator had to pay to the government a certain tax upon the produce of his soil, and probably also on the extent of his land, it was necessary that means should be had to ascertain precisely what was the extent, surface, or area, possessed by each. And as to all lands or soil surfaces the generic term "earth" was applied, the art of measurement of such surfaces came to be known as geometry—that of earth-measuring. In process of time the science and its applications became more and more extended, till now it includes within its domain all that relates to the space occupied by what we call surfaces—figures or outlines—and the bulk, size or volume of the solid substances we call bodies.

Certain Terms used in Geometry.

Anything which falls within the domain of our senses is called by the geometrician a "body." Every body occupies a certain portion of space. Space cannot be defined: the idea of space comes intuitively to man, like that of time. Geometry in the abstract does not concern itself with the materials of bodies; it only considers the space which they occupy, or the bulk, size or volume they form. The meaning of the word "surface" is generally known; it is the line which separates a body from the surrounding space. It may be popularly defined as the face of an object. Surface has no thickness. Geometrically or abstractly considered, what is termed a "line" results from or is produced by the intersection of two surfaces: and as a surface has no thickness, it follows that a line has neither width nor thickness. What is called a "point" results from or is produced by the intersection of two lines; and has therefore no dimensions in any direction.

Surfaces.—Figures.—Line.—Point.

A surface having only extent, that is, width or breadth and length, but no thickness, and a line the result of this intersection or cutting of two surfaces, having only length but not breadth, a "point," which is the result of the intersection of two lines, can only have *position.* Surfaces are made up of boundary lines, conceived of as existing in space, and all surfaces so formed are in geometrical language called "figures." But to construct figures for practical purposes, the points and lines of which figures are made up, and which give creation to them, must be visible to the senses. We thus give to a point actual dimensions; for whether we make it by means of the point of a needle, the sharp end of the leg of a pair of compasses, or by that of a pencil or a pen, it is possible to be measured, however minute. And so in making or drawing a line, whatever be the instrument or implement by which we form it, however fine it may be, it also in its breadth can be, as it is capable of being by delicate instruments,' measured. Mechanically we can produce a point by any instrument adapted to the purpose; geometrically it is produced by the intersection of two lines. And a line considered by itself has been defined as a junction of a series of points.

Plane Geometry, then, may be defined as the science of "figures," teaching us how to solve by their aid certain questions whose utility has been made known to us by the developments of the different sciences. Solid Geometry is concerned with "bodies." Of those two great divisions of the science, known by the generic title of "Geometry," we take up first that of "Plane." We commence our various sections of the science of figures by defining a number of terms frequently used in its study and practical application.

Right Lines—popularly termed Straight Lines.

The first subject we direct attention to is that of right lines, or, as they are popularly termed, straight lines. We have endeavoured to define what a line geometrically or mathematically considered is. But as an elegant French writer on the subject says, however ambitious may be the human mind in the use that it makes of its reasoning powers, it must nevertheless resign itself to leave certain things without definition, as certain truths without demonstration. This is the case with the straight line. We have simply an idea of it, nothing more; and this idea we have acquired by the habitual contemplation of the various objects surrounding us in daily life. All the definitions which have been attempted to be made of the straight line are only explanations *a posteriori*—that is, from the cause to the effect, and it may well be doubted whether any of them could convey the idea of the straight line to a man deprived at once of the senses of sight and of touch.

Characteristics or Properties of the Right or Straight Line.

We must content ourselves with the idea merely of the straight line. But from this we attribute to it the following properties: 1st, It is everywhere identical to itself, in whatever way it is turned,—it never changes; 2nd, It is the shortest way between any two of its points; and, lastly, through two given points we can make only one single straight line pass, and no more.

Conclusions drawn from the above-named Properties of Lines.

From these properties, or attributes rather, we conclude that two distinct straight lines can only have a single common point, for if they had two common points they would not be distinct. From the idea which we have of the straight line, we can conceive it to be indefinitely prolonged in its two directions. We draw a straight line, or by abbreviation a line, through two of its points, which we call *a*, *b*; it is thus that we give it the name of a straight line—that is, the line which passes through the two points. If we had to consider more particularly the portion comprised between the two points, we should say the portion or segment of the straight line, but for the sake of brevity the straight line *a b*, or merely the length *a b*.

Lines other than Right or Straight—The Bent or Zigzag Line—The Curved Line.

A line composed of consecutive portions of different straight lines connected with or joined to each other, but going in different directions, is by some called a polygonal or irregular line: the best idea of this is given in the popular term "zigzag." If a line be neither of this character nor a simple straight line, it is a "curved line," or more simply a "curve." We give to the lines, either zigzag or curved, certain qualifications which depend on their form. Thus, for example, a line is said to be closed or determined, when in starting from a given point of this line, and following its contour, we come back again to the starting point.

A Bent or a Zigzag Line, or a Curved Line, returning into itself or closed, forms what is called a Figure.

A zigzag line thus returning into itself, to the same point from which it is started, gives what is called a form or shape or a configuration, more simply a figure: and according to the number of turns the zigzag makes we give a name to the figure. The fewest number of straight lines required to form a figure is three, and to this we give the name of a "triangle." If there are four lines forming the figure, we call it, according to their length and their position in relation to each other, either a "square,' a "rectangle," a "parallelogram," a "rhombus," a "rhomboid," or a "trapezium" or "trapezoid." If the figure is made up of more than four lines, we begin a series of what are called "polygons," that is, many-sided, but to which definite names are attacded according to the number of lines. Thus a five-lined figure is called a "pentagon," an eight-lined one an "octagon." Figures such as those now named may be regular or irregular.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

The Technical Points connected with the Varieties or Breeds of Cattle—Their Breeding, Rearing, Feeding, and General Management for the Production of Butchers' Meat and of Dairy Produce.

CHAPTER IV.

In preceding chapter we gave in its last paragraph an illustration of a prize Shorthorn Ox. The general characteristics of the frame or contour of the breed, or its points, will be also fully illustrated and described hereafter.

It was in the early days of the breed often called the "Tees Water." Its history is a very involved and tangled one, the facts or circumstances recorded by some being disputed or contradicted by others; while beyond a doubt many, which would be of exceeding interest now, have been lost beyond all hope of recovery. Nor is this difficult to be accounted for. We have parallel cases in abundance in branches of industrial work other than that of farming or grazing. Inventors of machines and processes, especially in the early days of certain branches of work, were anxious chiefly, if not indeed wholly, to make those improvements without which they saw clearly that no really valuable and profitable results could be obtained. This so absorbed their attention and consumed their time that they had none left to record the steps by which they went from one point of improvement to another, even if they—which is very doubtful—were able to trace back from any one point of advance to the first or natural step in improvement which they took, through all the minute details; and the truth appears to be that great inventors or improvers are thinking much more of what their work can for their present time do for themselves than of what posterity will think of them or of their work. Nor, sanguine as inventors or improvers are said to be as to the value which their successors will set upon their labour, is it given to every one to foresee, as it were, the outcome of any invention or improvement. The party inventing may have but a very limited conception of the potentialities of his design or process. Doubtless, if one had even a fairly clear conception of how the invention or process he was working at was in time to prove one of the great factors in working out the sum of our national prosperity, he might very well be disposed to sit down and patiently and fully to record all the facts and circumstances connected with his work. But, seeing that the greatest of successes are reached only through the obstacles of a quickly recurring series of failures, it may well be questioned if every one would have ventured upon the candid explanation of what those failures were—though the most of them would be conscious that there was much to be learned from failures; the "how not" being as valuable to the thinking mind as the "how" to do it. How often do we hear engineers, for example, regretting that our great inventors have not handed us down a record of all the steps of their progress! Such considerations are not without value; in truth, they possess much to our technical readers, and find therefore an appropriate place in connection with other papers on industrial subjects in these the pages of the Technical Journal.

Unsatisfactory, however, as are the records of the history of the shorthorn breed—which is mainly the history of modern cattle breeding, as the principles evolved by shorthorn breeders and the details of their practice have practically dominated the improvement of all other breeds—there is enough left on record to give a position marked enough to a few names as the practical originators of the modern breed. We have seen that the breed at one time was known by the names of the "Durham" and the "Tees Water" breed; they were, however, distinguished by other titles, such as the "Holderness," the "Lincoln," the "Yorkshire," and the "Tweedside." George Culley, the author of a work on "Live Stock," very frequently quoted as an authority—date of publication of the second edition being 1794, the first edition having been issued nearly a hundred years ago—seems to have been the first to give the name "shorthorn" to the breed, though with this he joined the term "Dutch." His reason for calling them the "Short-horned or Dutch kind" of cattle was derived from and based upon the following circumstances. First, that in many districts the regular name given to the breed was that of the "Dutch." Secondly, that their *locale* was almost exclusively along and in the neighbourhood of the east coast of England, facing, and therefore having the nearest and most rapid communication with the Continent on the opposite side of the Channel; in the districts along and contiguous to which animals of the same class or kind were in Mr. Culley's days bred largely. The English district in which the breed thus had its *locale* reached from the southern part of Lincolnshire down to the borders of Scotland. And the reader will have noted that the various names we have given as those by which the breed was at one time known indicated localities all along this stretch of coast, as the "Lincoln" and "Tweedside" breeds. A third reason for Mr. Culley assuming that the shorthorn breed was originally a Continental one, was that a well known breeder of his day, celebrated for having the best breed of shorthorned cattle—a Mr. Michael Dobinson, of the county of Durham—went in his younger days to Holland to purchase bulls, which he found of great service in improving his stock. It does not in any way militate against the conclusion here arrived at, that succeeding Mr. Dobinson, other and less careful breeders imported bulls from the Continent, which being bad, produced a very degenerated lot of animals; and these having their *habitat* in districts along the river Tees, gave a bad reputation to the breed, which it took a long course of breeding on other and more sensible lines to get rid of. Who the breeders were that at last gave the breed of shorthorns the high reputation they now have, we are now about to glance at: this reputation, as we have already pointed out, is, in fact, the highest, as of all cattle shorthorns bear away the palm everywhere and always as the most excellent.

Whatever be the conclusion arrived at as to the accuracy of the view just stated, that the shorthorn breed came originally from the Continent, there is unfortunately too little in the way of recorded well authenticated facts to enable any one to say with absolute confidence what was its origin. Beyond all doubt it seems, however, to be that for long this variety or breed of cattle was represented by animals so coarse in quality and bad in form that little was done in the way of improving them, simply because, as it seems, the few graziers and farmers of the early times who paid attention to the development of cattle had little or no encouragement to take this breed in hand as the basis on which to found a thoroughly improved breed. And in connection with this we certainly have the suggestive fact that Robert Bakewell—who may be said to be the parent or originator of the modern science of live stock breeding—after trying many breeds in order to arrive at a conclusion as to which would be the best to improve and found a new strain or blood of stock upon, did *not* select the shorthorn, but took that breed known as the "longhorn." Of this breed we shall in a future paragraph give a description: and in connection with this we may have yet more to say regarding Mr. Bakewell and what he did in promoting the interests of careful cattle breeding.

Description of the Shorthorn, the Breed "par excellence" of Modern Fattening Cattle, continued—The Early Breeders—Celebrated Breeders.

Of the early or earliest breeders but little comparatively is known. The Mr. Dobinson already named was one to whom the breed owed a good deal. Other breeders of the period were Mr. Hill, the Messrs. Culley, a Mr. Millbank, Mr. Hutchinson, Sir William St. Quentin, Mr. Charges and Mr. Maynard, of Eryholme, near Darlington, and several others, now scarcely known even by name. The last-named breeder, Maynard—or rather the breeders known by this name, for there seem to have been more than one of the family devoted to the improvement of cattle—deserves, however, to have a more frequently alluded-to place in the records of shorthorn history, inasmuch as from stock reared by them came the celebrated shorthorn "Comet," which has been named by one authority as "the veritable founder" of the modern breed. Mr. James Brown, of Aldborough, deserves mention here as one of the early breeders who did good work in the improvement of stock,—such good work, indeed, that Bates, hereafter to be specially alluded to as one of the best known of recent breeders—always maintained that "the first bull was the best," and this was bred by Brown, somewhere about the year 1770. But, however valuable this particular animal might be, his fame has been totally eclipsed by the celebrated bull "Hubback," which was bought as a joint venture by Mr. Robert Colling and a Mr. Waistell from a Mr. Robinson, for the small sum of eight pounds. This celebrated bull, which has been somewhat oddly termed the "Abraham of the shorthorn breed," was calved in the year 1770, on the farm of Hurworth, near Darlington. Comparatively little is known as to the points of this celebrated bull; but according to all that has been left with reference to him, he was an animal combining in a remarkable degree the capability to take on flesh with great rapidity, with lightness of offal and an almost perfect symmetry of form. His colour was not the more modern, and now generally popular "roan," but the old, and then highly esteemed yellow and white. The horns were clear and wax-like in texture, the eyes bright, yet mild, and the general expression of the face very pleasing. His "touch," or handling—these terms, or rather this term, already alluded to in preceding paragraphs, will be fully described when we go into the principles of breeding—was remarkably fine, so much so that no animal of the period could approach him in this most valuable characteristic. Although so little is now, or has indeed in most of our agricultural works ever been given, as to the good work done by early breeders in the improvement of the shorthorn, what has been given—and more might here have been added did our limited space admit of it—will suffice to show that great, indubitably great, as was the work of those breeders whose names—as those of Collings, Bates, and Booth—have become, so to say, stereotyped in all farming works as the true founders of the improved or modern shorthorn, those more modern breeders were greatly indebted to them. So much so, that in the opinion of some who are entitled to be taken as authorities, the term "the real improvers of the breed" should be given to the early breeders, some of whose names have come down—and, unfortunately, but little more than names—to us, others now and for ever unknown or unrecorded. There seems to be little doubt but that the breed, by whatever name it has been or was for a long time known, was established in the districts we have already in a preceding paragraph named, from what is practically time immemorial; that many farmers and graziers and landowners

This bull is thus described by a writer: "'Favourite' was a large massy animal, partaking more of the character of his dam ('Phœnix,' 16 in the above list), than that of his sire. He possessed remarkably good loins, and long, level hind-quarters; his shoulder points stood wide, but were somewhat coarse, and too forward in the neck. His horns also, in comparison with those of 'Hubback,' were long and strong. . . . He was a powerful animal and of good constitution." As a proof of this good constitution, it is stated that Mr. Colling used to show with great pride a fine large heifer from him of direct "in-and-in" breeding, of sire to daughter, granddaughter, and great-granddaughter, and so on to her of the sixth generation. The bull calves of "Favourite" were like himself generally, a little coarse, but possessed of good constitutions. "Favourite" was so esteemed as a sure getter that he was used as long as he could be used. He lived to be sixteen years old according to one authority, by the statement of another he was slaughtered when he was thirteen years of age. It will be interesting to note here the dimensions of the celebrated bull "Comet," to which reference has been more than once made. He stood at the hind-quarters a height of 4 ft. 11½ in., at the shoulder 4 ft. 11¾ in., to the knee 1 ft. 5 in., to the hock 1 ft. 6 in., from the ground level to the brisket 1 ft. 6 in., to the chest 2 ft. 1 in., the length of the animal from poll to tail 7 ft., length of the face 1 ft. 8 in., of the horns 8 in., breadth of the face across the eyes 10½ in., across the hips 2 ft. 3 in., girth or round, measured round the neck 4 ft., round the chest 7 ft. 4½ in., round the cheek and forehead 4 ft., round the knee 16 in., round the bone of fore-leg 8½ in., round the coronet of fore-foot 13 in., round the bone of hind-leg 10 in., round the coronet of hind-foot 14 in., round the hock 31 in., circumference of horn at root 8 in.

Devoting their energies, their business habits, and their skill in cattle to the careful establishment of the breed now known all the world over as the Shorthorn, the Collings, by their rare aptitude in judging the points of fatting cattle, and great skill in applying this to the breeding of stock, are now admitted to have been the first to introduce an altogether new era in the history of farming, and to which may be given the name of the period of the finest of animals selling at the highest of prices, both quite unknown before they began their labours. Beginning their work not much before the opening of the nineteenth century, they were able, by the end of its first decade, to get, as Mr. Charles Colling got in 1810, one thousand guineas for a bull belonging to his herd—a price altogether unexampled, and which tended to give that herd a reputation which it never lost. Great as this price was, it has in more recent times been greatly exceeded for some shorthorn *calves* descended from Charles Colling's herd were sold for within a trifle of five hundred pounds. With Colling the reputation of a breeder of the highest class was shared by another eminent man—Bates of Kirkleavington; and at a later period another great breeder appeared on the scene, in Booth of Killerby. Of this great trio, the two last named —Booth and Bates—founded "schools," so to say, of breeding, which have taken the lead, and have had numerous adherents, each class of which cleave with such remarkable loyalty to their school that not a few discussions have taken place as to which was the best, the "Booth blood" or the "Bates blood." Now, compared with the few who reigned supreme as breeders of the shorthorn in the early days of improving practice, we have breeders so many that their name may be said to be legion; and of this great number many have been and are now eminently successful. Of these we have not space to give even a bare list, and must therefore refer the reader to the pages of the farming journals of recent and comparatively recent issue for full information as to those modern breeders. We can only extend the early history of the breed of shorthorns by a brief paragraph.

Early History of the Shorthorn Breed.—The Eminent Breeders, Bates and Booth.

In the year 1810 the celebrated herd of Charles Colling, at Ketton, was broken up, and the animals brought large prices at the sale. One of the purchasers was Mr. T. Bates, who bought for the sum of a hundred and eighty-three guineas the cow "Young Duchess," two years old, by "Comet," dam by "Favourite." This cow became one of the, if not the most celebrated of the modern shorthorn breed. To her "blood" Bates kept unflinchingly, with but one exception, when he took a "cross" with the bull "Belvedere," of Stephenson's breeding; and to this perseverance in close breeding may be attributed the remarkable success with which Bates carried on and completed his career as one of the greatest breeders of modern times. But still the success with the one single "cross" with which he broke through his established rule, was in itself remarkable, for with the bull "Duke of Northumberland," the result of the cross (together, however, with two heifers of the pure "Duchess blood"), Bates took every prize which was offered at the first show held by the Royal Agricultural Society of England, at Oxford in 1839, a year now classical in the annals of British agriculture, as it was the commencement of work by this Society in advancing its interests in every direction, scientific and practical, of which it is impossible to overestimate the value and importance. With but a few more "prizes" Bates closed his brilliant and successful career.

THE COLOUR MANUFACTURER.

WITH PRACTICAL NOTES ON THE USE OF PAINTS AND DYES IN DECORATIVE WORK.

PART FIRST.—PIGMENTS.

CHAPTER I.

Introductory.

COLOURING matters as articles of commerce occupy a high place amongst all nations, savage and civilised alike; and as man becomes more educated and refined, their use increases. As few objects in nature are devoid of distinctive colouring, so also few manufactured articles used by man are entirely destitute of ornamentation by the application of either paint or dye in one form or another. The reader need but glance around him, in whatever inhabited place he happen to be, in order to realise this fact. Hence the importance and the interest of our present subject.

The manufactures of pigments and dyes are essentially chemical art. The former is, generally speaking, a simpler matter than the latter. Pigments are all either obtained from comparatively simple and well known inorganic dyes, whose composition is readily ascertained, or from a dye and a precipitating agent: but dyes are mostly produced from complex organic substances of which the composition is often but approximately known, and the properties but partially understood. It is convenient, therefore, to divide the subject of colours into the natural divisions of Pigments and Dyes. Some pigments are found in nature in a state ready for use, except as regards grinding and washing; but the majority are manufactured from entirely, or nearly, colourless materials by the application of methods dictated by the science of chemistry. And whilst many pigment makers do not profess to be acquainted with any of the principles of chemistry, yet they employ chemical methods, learnt by long experience, and they undoubtedly would profit by such knowledge, as they would thereby know their business more accurately, and would be in a better position to improve and possibly extend it.

What is a "Pigment" or "Paint"?

A pigment is a coloured insoluble substance which may be ground up to a fine powder and, incorporated with certain oils, etc., applied to the decoration of articles. When prepared, either moist or dry, in a state fit for applying with a brush or pencil, it is termed a "paint." These are our definitions, to which we will adhere throughout our article. The words pigment and paint may be slightly otherwise defined, but for practical purposes our definition is both accurate and convenient. Pigments are always insoluble in the water or other medium with which they are mixed in using; a colouring body applied in a state of *solution* constitutes a dye. Throughout our article we will employ the term "pigment" to denote the insoluble body in a state of fine division, either dry or in an aqueous paste, unmixed with other substance. The word "paint" shall signify a pigment mixed with certain substances, rendering it fit for application—such as drying-oil or gum. The term "precipitate" we will use to designate an insoluble coloured compound obtained from a liquid by chemical action, but not dried or collected and prepared for use in the arts. The word "lake" we will adopt to indicate a precipitate formed from a dye by the action of alum or other substance.

Principle of the Use of Pigments.

A clear conception of the principle involved in the application of pigments to ornamentation—as distinguished from the use of dyes and "stains"—facilitates the study of pigments and painting. In using a pigment as a means of imparting colour it is necessary to mix it intimately with a liquid containing a substance that will cause the pigment when spread out with a brush into a thin layer or coating, after drying, to *adhere* to the surface of the article painted, and so, lying on the surface, display its colour to full advantage, without being hidden by the medium used. In *common painting* the pigments are mixed with some such substance as an oil which, on drying, forms a hard transparent glue or size, which effectually cements the pigment to the article without interfering with its colour. In *fine oil-colour painting* oils and resins are used for the same purpose, turpentine being generally present to dissolve or soften the fastener used. In *paper staining* the pigments are applied by printing, mixed with adhesive matters, so that when the paint dries the pigment adheres—the substances used being chiefly glues and gums. In *coloured paper making* the pigment is mixed with the pulp. In *fine water-colour painting* the pigments are mixed with gum-solution; on drying the gum causes the pigment to adhere to the paper as firmly as is required. In *glass, china, and pottery colouring* the pigment, or material necessary to form it, is applied to the article, which is then subjected to a high furnace heat. In *cloth printing* the pigment is mixed with solution of some such substance as will, on subsequent treatment of the printed cloth, cause the pigment to adhere firmly to the cloth—albumen being the fastener generally adopted.

"Opaque" and "Transparent" Pigments.

Pigments may be classed as (1) "opaque," (2) "transparent," and a medium class as (3) "semi-transparent." These terms are self-explanatory, but the qualities of these three classes of pigments may best be understood by illustration. If we take red-coloured pebble, grind it into a coarse powder in a mill, and mixing it with some drying oil or gum water, apply it with a brush to the surface of a white basin, we get a red or pink colour: but if we now paint a blue-coloured article we obtain a *violet* colour—due to the mixture of blue and red: the light *penetrates* the red pigment, and the commingling of red and blue produces of course violet; this is therefore a *transparent* pigment, because it is possible to see through it. If instead of red-pebble powder we apply iron-rust powder mixed similarly, on both white and blue grounds, we get a red colour in *both* cases, and not a *violet* in the case of the blue ground, because the light cannot penetrate the rust, and hence this is an *opaque* pigment—it hides what is beneath it. A mixture of these two pigments would give us a semi-transparent pigment, producing of course an effect midway between the extremes. When we wish, in painting, to produce an effect by the blending of two coats or layers of colour, the top coating must be a transparent pigment. It must be remembered that the same pigment may be opaque or transparent according to the mode of preparation, as the transparence or opacity of a pigment depends chiefly upon the aggregation of the particles—in other words, on the *fineness* of the powder. Thus coarsely ground glass is transparent; very finely ground, opaque. It need hardly be said that no pigment is absolutely transparent; the term is only relative.

"Drying" and "Non-Drying" Pigments.

When oil is employed in the application of pigments the fixing of the pigment to the surface of the article painted is due to the "drying," or, speaking accurately, the *oxidation* of the oil, whereby a resinous, transparent skin is formed by the action of the air on the oil which holds the pigment in its place. Some pigments have the property of preventing or retarding this oxidation, and consequently the paint does not "dry"; such pigments are termed "bad dryers," and other substances are added to the paint to counteract this influence—to cause the oil to dry. These artificial paint dryers are frequently siccative substances, such as oxide and borate of manganese, the acetates of lime and lead, and sulphate of zinc. Some pigments aid in oxidising the oil, or at least offer no resistance, and hence are termed good drying pigments.

The Terms "Body," "Covering Power," and "Density," as applied to Pigments.

The covering power, or body of a pigment, is the amount of surface to which a certain quantity of it will impart colour when spread out with a brush. It is, as will readily be seen, an important factor in affecting the value of a pigment for industrial purposes; a pigment may be of a good shade of colour, but owing to its low covering power it may be too expensive to use, or inconvenient owing to the large quantity necessary to place on the surface in order to obtain that shade. *Density* means weight or specific gravity, when applied to pigments. These, and several other physical properties of pigments, have an intimate and important connection with their application in the arts, and we shall have occasion to treat of each separately in detail in their proper places in the course of our paper.

Some Chemical Properties of Pigments.

For certain purposes some pigments must have particular chemical as well as physical properties, without which they cannot be made use of. Thus, for many purposes, it is a serious objection to a paint to contain lead, as this in contact with coal gas containing sulphur becomes black. Hence the frequent objection to white lead—which is composed essentially of carbonate of lead—as a constituent of paints where coal gas or the fumes of burning coal have access. Other chemical qualities of pigments will be noticed under their proper heads: suffice it at present to remark that *any* coloured insoluble powder of the desired shade is not suitable as a pigment,—its properties, physical and chemical, must be considered. Pigments, moreover, must possess, in greater or less degree, certain qualities of fastness or a capability to resist the action of such influences as light, air, and moisture.

Division of our Subject.

Owing to the diversity of processes by which the various pigments found in commerce are produced, we have considered the best way to divide our subject to be that under the headings of the colours: namely, white, red, yellow, orange and buff, blue and slate green, violet, brown, black and grey. It must be remembered that the pigments of similar colour used by common painters, by paper stainers, by calico printers, and by fine-artists, are mostly produced by exactly the same chemical means, any difference in the commercial products being due to subsequent mechanical treatment in grinding and washing, etc.

Pigment Whites in Common Use.

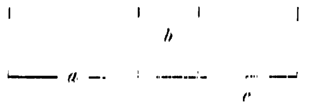
The pigment whites commonly in use are (1) white lead; (2) zinc white, French white or zinc oxide; (3) Griffiths' zinc white, white lead substitute or sulphide of zinc; (4) Baryta white or sulphate of barium; (5) lime white, gypsum, or sulphate of lime; (6) whiting. Whilst treating the subject of pigment whites, we will treat briefly of other white insoluble bodies which, although not commonly called "pigments," are yet practically pigments, and are used in the arts for a variety of useful purposes. These are (7) China clay, largely used in sizing or finishing cloth; (8) sulphate of lead, which occurs as a bye-product in the manufacture of acetate of alumina.

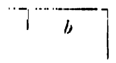
THE DOMESTIC HOUSE OR HOME PLANNER OR DESIGNER.

THE WORK OF THE YOUNG ARCHITECT OR BUILDER IN THE HOUSES FOR TOWN AND COUNTRY.

CHAPTER IV.

IN the concluding paragraph of preceding chapter, under the head of "position of doors in bedrooms," we advised the young reader to make pencil sketches of the plan of each room, tracing out all the possible arrangements of doors in relation to the furniture of the rooms; and that by doing this he would find that there were other points affecting materially the comfort of their occupants, than those pointed out in preceding paragraphs; and this especially in times of [illegible] required by the invalid is of great service. Th[illegible] although the door is best in the corner *a* in the [illegible] type diagram, as it gives space for the bed, *b*, to be placed in the centre of the partition wall next the lobby, *c*, this is also the best position, for it gives a space in the corner *d* for the "washstand,"—this being so placed that it will not interfere with the free working floor space of the room. The dressing-glass and table will thus be placed at the window, as in the second type diagram, in the position *b*, which is the best for it. Another position for the washstand might certainly be in one or other of the recesses *a* or *b*, in the third diagram, at the side of the fireplace *c*. But as those recesses should, in a well-fitted bedroom, in ordinary or middle-class houses, be filled in with permanently fixed wardrobe presses or cupboards, placing the washstand at either of those points, it would obviously be in the way of the easy opening and closing of the wardrobe doors. Again, as it is always convenient, in times of sickness especially, to have space at the side near the head of the bed for a small table to be placed there—the door *a*, in the fourth type diagram, should be placed as near the cross wall *b* as possible; this gives the space *c* between the door and the side of the bed *d*. This would not be given if the arrangement was as in fifth diagram, the space *c* being too narrow. Of course the reader will understand that the cases here illustrated are those only likely to occur in small bedrooms—which are, however, the rule, not the exception.





Further Practical Examples of such Important Points as the Foregoing.

Such points as the above—and other "small things," as by such phrase they are too often put out of court—are precisely those which make or mar the comfort and convenience of a house. Our [illegible] said, [illegible] in, not to look at merely; and what adds to the comfort of living cannot be in any sense unimportant—certainly far from trifling. The cases above [illegible] are much more difficult for the housewife to deal with where the bedrooms are *very* small, and where the planner has thoughtlessly placed the door in a bad position. And we may repeat the statement of the fact, the existence of which is certainly matter of great regret, that very small bedrooms are too much the rule in all classes of houses; but on this point of house arrangement we shall in a future paragraph offer a few remarks. Take this case for example; and such an absurdity in planning as this has been perpetrated. Let *a b*, in our sixth type diagram, be part of a bedroom, *c* a small dressing-room or linen-closet, entering from the bedroom at *d*; *e* the door to the bedroom entering from lobby *f*, from which also a small closet *g* is entered; *h* the window. The fireplace, *i*, of the bedroom is placed in the *centre* of the wall which is opposite *d*. Now where can the bed be placed? Not in the corners on either side of the fireplace, as at *j* and *k*, for they are far too narrow; nor in the corner *a*, for the bed would then project beyond the line of the door, *e*; or if this door were even farther from the wall *d b*, the bed would still come beyond the door *e*. The bed can in this case be placed only in the corner *b*, and the end of it will project so as to block up part, if not the whole, of the window *h*. All such absurd difficulties should never be met with. And they would never be, if in planning a house special

plans on a larger scale of the bedrooms were taken, and the bed space put down therein in all positions, so as to ascertain which would be the best for it to occupy. If this were done, in many cases the planner would see that his bedrooms, however well and conveniently placed they seemed to be in the *general plan*, would not do when coming under the hands of a housewife who has to arrange the furniture of the rooms and make them, what they should be, convenient and comfortable. How often do we hear the complaint made, "Oh, the house is very nice in many ways, but it will not do for us, —we cannot get our furniture into the bedrooms, so as to move about comfortably in them,"—which, to our mind, is very much like saying, "Oh, the house is a very good house, but it cannot be lived in." Surely living in a house is precisely the object for which it was built, and no other.

Practical Points connected with Doors as affecting the Convenience of Rooms.

The mere hanging of a door is a matter of some importance. Doors to cupboards, pantries, etc., are frequently hung in such a way that when opened they actually shut out the light of a window, as when it is blocked up by the door of a closet hung so as to open against the window, keeping at the same time the light from the closet. Now, by hanging the door on the side farthest from the window, when it was open the full light would be thrown into the closet: a great convenience, surely, in looking for or arranging things. At the same time the light from the window would not be so much obstructed.

All doors to small rooms, as dressing-closets, entering from a larger room, should, as a rule, be made to open into the larger room. By reversing this method much of the space of the small room will be lost. Thus we have known a dressing-room attached to a bedroom rendered most inconvenient by having the door opening *into* it. As thus: in one corner of the dressing-room was the wash-hand-stand, in the other a small chest of drawers; the door opening into it, between the two pieces of furniture, in such a way that any one standing in front of the drawers and wishing to get into the bedroom had first to shut the door, then pass to the space in front of it, then open the door and pass out; whereas all this could have been avoided by hanging the door so as to open into and against the wall of the bedroom. So also in the hanging of doors opening into narrow passages; this should if possible be avoided, especially if the doorway is in the centre of the passage, so that one may have occasion to go farther along it: the passage is, in such a case, fairly obstructed by the door opening into it, if the passage be narrow, by being so near the opposite wall that there is no room to get past it till the door is closed.

Hanging of Doors of Water and other Small Closets.

In water-closets, from their being made as a rule so small, the inconvenient mode of hanging the door so as to open *into* the closet is specially annoying, as many of our readers must have experienced, especially in town houses. In such cases, as they often enter from a passage, of the two evils the least should be chosen, and the door should be made to open to the passage—although that may be, as named above, inconvenient—in place of opening into the closet. The hanging of doors of water-closets and privies is generally carelessly done: for example, this, than which nothing could be more awkward,—the party walking in has first to open the door, then crush himself up into the corner opposite to it, then shut the door to get to the seat; the process being reversed is just as absurdly tedious in getting out. All this could be avoided by simply hanging the door so that it would open against the outside wall. And as privies in a very large number of cases in the houses of the working-classes, and the houses immediately above this class, are built in the backyard, there is no excuse for lack of room for the door to swing freely in. But this case applies also to closets placed in the house, although not to those which are large and roomy—as all closets should be—as there is then room enough for the door to open inside. And this would be, perhaps, the better arrangement: as placing it to open outwards, it might come in contact with the door of an apartment or closet near to it, the door of which might also open outwards. Nothing is more disagreeable, and, indeed, dangerous, than doors clashing against each other when opened under such conditions of hanging. It would be easy to multiply examples of badly hung doors, but we have given enough to show that some amount of attention at least is required in this department of house-fitting, where perfect convenience and comfort are wished for.

Such Points as

The same careful thought should be given to every part of a house. It is of little use to say that many points are mere trifles. We have shown that nothing which concerns itself even in the slightest degree with the health, the comfort, or the convenience of those who live in the house is trifling. The architect no doubt thought it but a trifle that the kitchen not, be it remarked, of a cottage, or even of a middle-class house, but of a large and costly mansion he had designed—should be reached by three steps, and these, moreover, at the beginning or end of a long passage, much more distinguished by its dark gloom than by the clear light it ought to have possessed.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER IV.

THE last paragraph in preceding chapter concerned itself with what to some may appear a point in the practice of the draughtsman of no, but is in reality of considerable importance—namely, the handling, *i.e.* while examining drawings, more especially if they be finished and elaborate, being in that case the more costly and valued by the draughtsman. But the point obviously relates to the way in which clean sheets of drawing paper are to be used for putting down drawings on. For it is of great importance to have a sheet perfectly flat, uncreased or unwrinkled, to work upon. All this, as we have said, may to the young draughtsman appear a very small or very trifling matter, quite beneath or beyond his careful notice. He will not think it either small or trifling if he has spoiled for him by some careless fellow, or carelessly spoil for himself, some valuable drawing which from the labour bestowed upon it he takes a pride in. And he will have read to little purpose what in such a case we shall have written to as little effect, if he fails to see that we have had the desire at least, in so writing what we have, to give him some hints of true practical value on points of his work as a draughtsman, and specially as a designer, other than those merely connected with the stretching of his drawing paper on the board. We deem it our duty here, and in all things we have to dilate upon, to inculcate the importance of his *thinking over all the points of his work so that it be done in the best possible way for him to do it in.*

The Gluing or Gumming Down of the Damped Sheet of Paper on the Drawing Board.

In the "stretching" of his paper on the drawing board, the draughtsman has now got the sheet lying on the board, with its damped or sponged face downwards, and with a uniformly flat, uncreased front. It is now to be secured to the board. This is generally done by the medium of glue. Some prefer gum, as being a more sightly and cleaner substance, and one more grateful to the olfactory nerves than glue is.

If gum be used, however, it is essential that it be made in a strong or thick solution, otherwise it will not hold. The glue or gum being prepared and kept in a clean vessel, covered when not in use to keep out the dust, the next process is its application. Take the T-square, and apply it to the board, so that its edge shall be from five-eighths to three-quarters of an inch from the edge of the paper; bend back the paper so that it shall lie, or partly lie, on the flat surface of the blade of the square, and in this position apply the gum or glue all over the lapped point or "margin" of the paper, and, of course, on its under side, or that which will be the under side when it is put or bent back again on the surface of the board. The finger is by far the best, although to some fastidious draughtsmen it may not be the most pleasant way, to apply the gum or glue to the folded or bent-over edge of the paper. The gum or glue should be spread not too thickly, but uniformly, over all the surface of the edge, and this uniformity will best be secured by the finger, as the sense of touch—one of the most delicate in its indications, of the human body—will come to the aid of the draughtsman. When thoroughly and uniformly glued or gummed, the edge is folded or placed back again, so that the glued surface lies on the board. The finger—not the glued one—should now be used to give dexterous strokes over and along the surface and firm pressure to the edge, so that its contact throughout with the board be secured, by all the air-bubbles being thoroughly pressed out. The upper edge of the paper is now secured, and all the other edges should be as rapidly secured as possible in the same way. This rapidity—consistent, however, with completeness or thoroughness of doing—is essential, for it must be remembered that the process of "stretching" or "contraction" of the paper is begun at the moment it is placed on the board, and if all the edges or margins of the paper be not quickly secured, it is obvious that unequal and imperfect stretching will be the result, for the margins not secured will "give" or yield.

Some draughtsmen use glue in the solid state to fix down the margins of the paper. Taking a longish and thickish piece, with a smooth edge—the longer it is used the smoother will the edge, of course, become—they either wet the edge with their lips, or, if more fastidious, by dipping it in water, and rub it quickly and evenly over the surface of the margin, as it lies face upwards upon the blade of the T-square. Rubbing is continued till sufficient of the glue is transferred to the paper, when the margin is folded back, and pressed by the finger closely to the surface of the board. No doubt this method, when well carried out, gives a good hold to the paper, but it is obviously one which takes longer time than the application of liquid glue or gum, and we have seen that rapidity of gluing or fixing down is essential. We have found in practice that the liquid form for the securing substance is equally efficacious, and if gum be used, much more cleanly and binding. All the margins or fold-over edges being now secured, the drawing board should be tilted—at an angle, to prevent its falling forward—up against the wall, with its paper side nearest this, until the sheet dries thoroughly. When this takes place, it will be found that the sheet is tightly stretched on the surface of the board, without a "crease" or "buckle" or "bend" on its whole surface—that is, if the stretching has been well done. The drying should be done slowly, to which end, if there be a fire in the drawing office or room, the board should be placed as far from the fire as possible. Some, in their eagerness to have the process finished, will purposely put the board near the fire. When they do so, they often find the truth of the proverb exemplified, "the more haste the less speed." For the stretching or contraction of the paper—for in truth it is a contraction, not a stretching, in the true sense of this latter term—goes on much more rapidly than the drying of the glued or gummed margins, which have to resist the strain of the contraction, and these will be found to give way in parts; and in so far as they do give way, all the benefits of the process are lost, for the sheet will then present a most uneven surface. Let the young draughtsman, then, put the drawing board, when the process of "stretching" is completed, as we have described it, as far from the fire as possible, and "in patience possess his soul." And as there is no mental attribute more called upon in his often complicated and trying work than that of "patience," without which and its sister virtue of perseverance he will never become an able draughtsman, the sooner he begins to exercise the virtue of patience the better for himself and his prospects. Let him, then, make this, the first of his actual work as a draughtsman, the first trial of his patient waiting.

Difficulties and Disappointments connected with the "Stretching" System of securing Paper to the Drawing Board.

But with all the care possible he will often find that in this process of "stretching" his paper his "labour has been lost." The contractile force of the paper as it gradually dries is very great,—much greater, in fact, than most young draughtsmen will be inclined to believe. We have seen paper stretched upon a badly made, yet apparently, and in reality, comparatively strong board, put such a strain upon the wood that it has fairly bent round the board till its paper side or surface was concave. But this contractile force, which the paper exercises as it slowly dries, sometimes—and always too frequently and annoyingly—brings about a catastrophe which makes all the previous labour useless. For if there be a weak part of the paper—and this is often created by having some part too highly wetted—this part will under the great contractile strain of the drying paper give way; and the rupture is so complete and sudden that it will often announce itself to the ears of the disappointed and inexperienced draughtsman by a sharp crack or report like that of a small pistol. When this happens there is no remedy: the stretching of a new sheet must be gone through with, with what patience and grace the draughtsman can call up.

First Lessons of the Draughtsman.

On the supposition that his work meets with a better fate than this, and that he has a sheet well secured on his drawing board, either by this, the stretching process, or by one of the other two methods described in a preceding paragraph, the draughtsman is now ready to begin his work. To which end we presume also that he is supplied with the necessary instruments. We do not at this stage of our paper deem it necessary to give either a list or an individual description of these. What brief description we shall give will be more in the way of showing how to use them than in that of explaining their peculiarity and construction. Nearly every one is familiar with the instruments, and if not, a few minutes' inspection of those we name as essential to the young draughtsman will do more to show their peculiarities than pages of laboured description. What we have to say on each, so far as their use is concerned, will be given at the points in our paper where we explain the different stages of the draughtsman's work.

His earliest efforts in this will necessarily be of the simplest kind, and will at the start consist in the drawing of simple lines. What the varieties and peculiarities of lines are, and what the problems connected with them, will be found in an early chapter of the series of papers under the name or title of "The Geometrical Draughtsman." The draughtsman will find, as he here proceeds, that many of the problems given in this last-named paper will be done in a much more simple and ready way by the use of the drawing board and the T-square, and the other appliances to the use of which we shall forthwith direct his attention.

Pencilling of Lines—Varieties of Pencils—How to Choose and Prepare them for Work.

As all drawings, however simple, are put in in pencilled lines, the "choice," "treatment," and "use" of a good pencil is a matter of importance. Time was, and that at no distant period, when "choice" was extremely limited,—it indeed had but few points of variation between what may be called the normal extremes of very good and very bad, or at least very poor. And, unfortunately for the impecunious or moneyless young draughtsman, the very good pencils were dear, while the very bad, though much cheaper, were dear at any price, so far as usefulness as a pencil which could be pointed and used to give a good clear line was concerned. For a good drawing pencil with a special brand, such as H H, or H H H, or an F, or a B, one shilling was then the regular price. And as for the penny pencils of the period, the less said about them *as* pencils the better. Now all this is changed, and pencils can be purchased at the price of one penny under any of the brands or marks in regular use, which are positively of better quality than many of the shilling drawing pencils of thirty or forty years ago.

THE FACTORY OR MILL HAND AS A TECHNICAL WORKER.

THE ORGANISATION, GENERAL DUTIES, AND SPECIAL WORK OF THE STAFF OF FACTORIES FOR THE PRODUCTION OF SPUN AND WOVEN GOODS—THAT IS "YARN" AND "CLOTH"—AND THOSE CHIEFLY IN COTTON AND WOOL.—GENERAL DESCRIPTION OF THE VARIOUS PROCESSES OF MANUFACTURE.

CHAPTER III.

Brief Glance at the Great District of our Textile Manufactures *continued.* - Its Practical Suggestions.

IN the preceding chapter we gave under this head a variety of notes, ending these with a description of Stockport. These notes we now continue. A very few miles distant from this town we come to a district where cotton spinning and manufacturing is again the staple of industry for scores of thousands of hands, and where tall chimneys are the rule—Ashton-under-Lyne, Staleybridge, and the vicinity.

The spinning and manufacturing in the town of Ashton-under-Lyne is of various kinds—*i.e.* from coarse counts of yarn to medium and even to the lower numbers of fine yarns. The manufacture of cloth is more varied in consequence. This town is not marked for its possession of considerable millwrights' or machinists' works, though it has several small works of the kind necessary for general repairs. Passing on about a mile farther, we arrive at another busy town, Staleybridge, a very old place, with many very old mills. The class of work here is also varied—*i.e.* from coarse counts of yarn to what is termed fine yarns - ranging from 80^s to 140^s. There are two or three machine makers who make a variety of machines, and one or two classes of machinery which rank with any in the trade.

We have now given a general statement of the various towns, and of the class of goods they make, and have also hinted at the machinery made in each town - *i.e.* such machinery as is required in producing cotton yarn and cotton cloth. It would be out of place at this early period to attempt to describe the various machines which are used in cotton mills. Their description will be given as we proceed, beginning with the raw cotton and tracing it in each stage to the finished thread or yarn and cloth, where it will be ready for the dyer, bleacher, or printer.

Still, numerous as are the towns, large in their aggregate as are the numbers of their population, and vivid to some extent as is the idea this feature gives of what the cotton trade is, it requires more the distinct utterances of statistics to enable readers to arrive at an accurate conception of the important part the cotton trade plays in our general manufacturing industry. Numerous as are now the recorded facts and figures which make up the resources of our statistics of the trade, we need not go far back in our endeavour to know what these were, for it is only of comparatively recent years that anything like a well devised system of making what are technically called "returns" of our textile or indeed of any of our manufactures was adopted and carried out. It may indeed be stated with some degree of certainty that before the period of the introduction of the first "Factory Act," passed in 1833, all we know as to the actual condition of the trade was but little better than any knowledge could be—if indeed this term can be truly here applied—which was founded upon very general inquiries, or what is worse, although it was most frequently the case, upon mere conjecture or guesswork. Even now the official "returns" are not so full nor so complete as, and certainly they are not published with the frequency and the celerity which, their importance demands. Still we can obtain from them on the whole a fairly accurate view of what the condition of the cotton trade is. We may, perhaps, find space in a future paragraph to glance at some of the leading statistical facts of the cotton and other textile trades. Meanwhile we leave this, not usually very interesting reading, to take up the more useful and instructive matter of our paper.

First Process or Operation through which the Cotton is passed on Arrival at the Factory or Mill—The Mixing.

Having in Chapter I. very briefly mentioned the process of "picking" or "gathering" the cotton from the pods of the cotton tree, and the preparation for the "gin," and the "packing," and named further the countries from which the bulk of our supplies of cotton are derived, and their qualities, together with the minimum and maximum lengths of the fibres, we now present the reader with a description of the first movement which is made when the cotton reaches the warehouse at the mill. It is weighed as a matter of course, and in most mills the owner or his representative sees that each is "sampled" and the samples of each bale compared with the sample which it was bought by; there being very often a slight difference in the fineness or coarseness, or a variation in the length of the staple. If the cotton from any of the bales should be much longer or finer than that from others, these superior qualities are kept on one side for a better class of work or goods, where two or more qualities are made in the mill. If the whole of the bales are laid without any selection, which is very often done, the reader will see that the plan of mixing various qualities together cannot be secured. But this mixture is very desirable, as it must insure a more regular "mixing," and consequently a more uniform quality of yarn can be produced from it than by using one bale at a time. Most spinners when they buy cotton for one mixing purchase one class, *i.e.* all American, or all Egyptian, etc.

Mixing of Different Qualities of Cotton Wool.

The "mixing" being decided upon, the bales of cotton intended to be mixed are laid down side by side near to the place where the mixing is to be made. In mixing, in order to insure regularity, a layer is taken off No. 1 bale and spread all over the mixing floor; another layer is then taken from No. 2 bale, and is spread over the portion of No. 1 which is spread on the floor, and so the process is carried on until a portion of each bale is used; then returning to the No. 1 bale, another layer is taken, and spread out as before, and so this alternate process is carried on until the whole bales are mixed. In order to further mix the different layers or parts of the bales, a very simple means is adopted whereby this is insured - by using a strong iron rake, the teeth of course being set apart much farther than that of a garden rake (say about four inches). The person who is appointed to take the cotton from the mixing is expected to rake down the breast of the layers, so as to make the mixing of the bales still more uniform throughout. This method of proceeding with cotton, and the mixing of it, before it is subject to any application of machinery, is the one most generally adopted in cotton mills. Thirty to forty years of experience in the general work of factories warrants us in saying that it is the most efficient course to adopt, in order to gain the best result in this the first operation of factory or mill work. We desire to impress on our readers the importance of doing everything thoroughly in every department; for be it understood, if a mistake is made, whether in the first manipulation or in any other part of the process of spinning or manufacturing, it cannot be fully rectified afterwards, however much time and care be applied to do it. The adage "prevention is better than cure" should be our motto through life, whether it pertains to us individually or collectively. It is necessary to note, in reference to the title of this paragraph, that the term "wool" is oddly enough applied to cotton; it is so, however, in order to distinguish the substance when in its original or fleecy or fibrous, from its manufactured condition. In the latter case the term is cotton "cloth," or simply "calico."

The Second Process through which Cotton is put in the Factory. —The Opening up of the Fibres or Lumps of Cotton from the Compressed Bale. - "The Willow."

The first operation above described gone through, there follows that of opening up the lumps or masses of cotton, so that the fibres shall be as loose as possible. The machine used for this is called the "Willow" or "cotton opener." This machine is, generally speaking, of a somewhat simple make; some are more complex. The one which is in use very largely where a very low class of cotton is used —say "Surat," or any other kind of cotton of the like nature—is termed an "Oldham Willow." Some of our readers will at once see the necessity for the operation of some machine by which the cotton can be changed from the matted condition which packing by hydraulic pressure, and with a little moisture added in every few layers, gives it. Before describing the "opener," it will be as well to glance at one reason at least for the immense pressure which is applied in the packing of cotton. Most goods which are carried by water are charged by bulk, and therefore such bulky materials as cotton would cost a considerable sum in carriage if not pressed into as small a compass as possible. The cotton opening machine requires to be made strong in all its parts. The cotton coming from under such a pressure must of necessity be closely matted together, like any other material which has been placed under great fibrous pressure. The "opener" - "the Oldham Willow"—alluded to above is made by most machinists. Each machinist may make some little improvement in some department, but still the original principle of the machine is maintained. The machine in its outer form is almost square, but the working part, where the cotton is operated upon, is cylindrical. A cylinder which carries a series of what are called spikes, revolves rapidly within this part; and at the top of the machine there are fixed flat bars, which also carry spikes, sometimes called "teeth." The teeth, or spikes in the bars, are so arranged that the spikes in the cylinder pass between those in the bars, and in this way the entangled or lumpy parts get separated. In addition to the cotton coming in contact with the spikes, and being then somewhat opened, it is further driven about with the draught —a current of air produced by the very rapid rotation of the cylinder. Thus the cotton is driven against a series of fixed bars or grating, and this process cleans or frees it to a considerable extent from seeds, shells, and sand, and it is thus changed from a lumpy condition to that of a light material. Being freed somewhat from sand, seeds, etc., it has a much brighter appearance, and is also more suitable for the machine next in sequence, called the "scutcher" or "blower," hereafter to be described.

Cotton Opening by the "Porcupine" Machine.

Another cotton opening machine, which is used in some districts largely, as being more suitable for the various classes of cotton, is called a "porcupine." The cylinder in this case has no spikes or teeth which resemble those in the "Oldham Willow." This machine is fed with cotton, on to what is called an "endless apron"—*i.e.* this apron being like an endless lap, having rollers put into the inner part at each end, and those rollers being driven by other parts of the machine, causing it to travel along continually. The cotton is thus carried forward to what are called feed-rollers. These feed-rollers, running at a very slow speed, of course carry the cotton but slowly. One of the "porcupine" cylinders—most machines of this make contain three or four "porcupine" cylinders—being set close to the feed-rollers, and running at a considerable speed, *i.e.* some hundreds of revolutions per minute, and the cylinder having a considerable number of what may be termed "teeth," set very much closer together and smaller than the spikes of the "Oldham Willow," is intended to separate the matted, lumpy parts of cotton by taking it from the feed-rollers in small portions; and as these small portions are taken round by the first "porcupine" cylinder, they are delivered to the second, and so on until the whole of the cylinders have had their share in the opening-up process or dividing. The cotton as it leaves the porcupine machine can be left either in a loose, open, downy condition, or may be made into a lap in the same way as the laps are made at a scutcher or any finishing "lap machine," hereafter to be described. The "porcupine" opening machine, when it was first introduced, was said to be a machine which would quite supersede the "Willow." As time passes on new ideas present themselves to the ingenious, and in time others are brought out in the place of those which are and have been in use for a long period. All new ideas are not necessarily, as some think, always advantageous, or in any degree in advance of those which are and have been in use for many years. The principles of the cotton machines rarely, if ever, change from their original plan; though different in form, they still maintain their original basis of operation. We believe that all, or nearly all, machines are improved, but still adhere to the original plan to a great extent. This indeed is a remarkable feature of the mechanism of the cotton manufacture, the original inventors seeming to have hit exactly upon what the machine was required to do, and the peculiar mechanical movement or movements required in the doing of this.

The Vertical Cotton Opener.

The machine which we next refer to is one to-day largely in use. The working parts of those above alluded to are on the horizontal principle, but the one we are now about to advert to is in the working part "vertical." This principle has its advantages over the other arrangements we have previously noticed. Wherever power for turning is required, it is of importance that regard to that should be had, as it is a continual expense in fuel. Where, moreover, an increase of power is required, there is an increase of friction, and an increase of friction means more wear and tear and more attention, more oil or other lubricating substance; hence the advantage of having machinery so calculated and arranged that expenses in working will become minimised. The opening machine now to be noticed is one of this class, it being vertical, and the foot of the spindle working in a step with a bearing at the top. It will at once be seen that, the spindle-foot being of so small a surface, and the weight of it resting on that foot, the friction must be much reduced. Our readers would do well to experiment on such simple matters (we allude to those who have not had the opportunity from experience to prove it), and, simple as it may appear, it will cause the studious reader to think out other matters. It is well for the technical worker to note that all large questions are composed of many small points. It often happens that small things are cast on one side as unworthy of notice. This reminds us of a young woman, a household servant, whom the housekeeper was teaching to read. In course of time she began to pass over little words, such as *to*, *is*, *it*, *if*, etc., etc., and when her teacher said to her, "Jane, you have passed over so-and-so," the answer was, "I will not be bothered with such little insignificant words." We know from observation and experience that the same principle is carried out too often in the everyday work of factories, many thinking a little matter (even where principle is concerned) to be unworthy of thought. To return: this method of cotton opening requires much less power than the horizontal beater shaft, consequently involves the use of less oil and less power, while the "wear and tear" is also consequently less. The above are not the only considerations connected with the machine. In all fibrous materials it is of the greatest importance to have machinery of the best make, so as to secure the "staple"—*i.e.* the fibres—from injury, *i.e.* from breakage. This vertical opener has this advantage: though an iron machine, like others in that respect, it is very unlike others in the method of opening the cotton. The cotton is conducted to the beater by two iron rollers (feed-rollers). This feeding arrangement constitutes really the ground of complaint with the ordinary beater; for as the cotton is drawn through by the feed-rollers, it is held fast by them for a time, while the beater is striking against the cotton with a terrific force, and with successive strokes at the rate of, say, 2,800 blows per minute (two arms in the beater). The speed of the beater, as given, will afford some idea of the chance which each tuft of cotton has to be punished, so to say, by this rapid process. Each piece of cotton, say the length of a man's thumb-nail, receives at least from a hundred to a hundred and fifty blows per minute. Although the feed-rollers are continually moving, the rate of motion is slow, and the beater having two arms, two strokes or blows are given at each revolution of the beater to the cotton, which is held fast between the feed-rollers.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER V.

CONTINUING our description of the colour-box and furnisher given in last chapter, it is to be noted that the colour-box is fitted with screws, to allow the printer to lessen or increase the pressure of the furnisher against the engraved roller as required. In some cases a brush-furnisher, made of stout bristles in the shape of a roller, is used, but only when the colour has a tendency to clog or stick in the engraving.

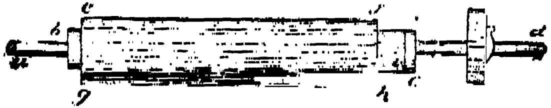


Fig. 9.

8. *The Clearing Doctor* (fig. 10, *a b c d e f*).—There are several qualities of doctors, of which the ordinary steel doctors which are in general use are the best, and mostly applicable for all styles. In cases where the steel would be acted upon by an acid in the colour, copper or nickel-plated doctors are adopted.

The doctor is composed of a thin piece of steel, sufficiently tempered that it may be cut by a good file, placed between two pieces of brass called doctor-shears, fitted with tightening screws; after the doctor is packed perfectly straight in the frame, the tightening screws are screwed up, securely holding the blade in its place, firm and true. To the pieces of brass or doctor-shears are fitted two levers, bent so as to come under the colour-box, on which are hung weights to originate the necessary pressure of the doctor against roller. There is an arrangement of lever attached to the centre of the doctor, and connected with an eccentric fixed on the axis of the bowl, by which a steady, gentle, vibratory movement is given to the doctor, thus the more effectually removing the colour from the smooth parts of roller, and also preventing the doctor from wearing unevenly. On each end of the doctor-shears, and close to where the levers are fastened, is a small centre, which fits into small brass steps, fitted with screws to move them away or closer to the roller as required. These are called the doctor steps. The doctor is pressed against the roller at a tangent. It is the object of this doctor to scrape off all the surplus colour on the roller, taking it off the plain parts and leaving colour in the engraved parts, which at once comes in contact with the cloth to be printed. The printer's art consists chiefly in whetting and adjusting his doctors, as the slightest roughness on the edge of the doctor will spoil the print, so that the doctor is one of the most important parts of the machine.

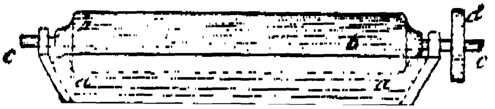


Fig. 10.

9. *The Lint Doctor* is a similar one to the clearing doctor, but presses gently on to the roller *after* the latter has printed the cloth, and therefore between cloth and colour-box, for the purpose of catching any dust or lint that may fall into the colour, either from the roller itself derived in passing over the cloth, or from the cloth above.

Having described the main parts of a printing machine, we now take, as an example, our machine, and describe it more fully.

Description of a Twelve-colour Printing Machine, drawn in Plates XXII. and XXIII.

We give in Plate XXII. the drawing in elevation of a twelve-colour printing machine, and in Plate XXIII. the drying apparatus connected therewith. We proceed first to describe such details of the machine as are shown in the diagram, and then trace the working of the same. It is well that we should mention that the machine we now describe serves only as a *type* or *example* of the machines now manufactured, as many details—and important ones too—differ in different makes of machine. Thus the apparatus for washing and drying the back-grey is generally dispensed with, that operation being performed entirely separately from that of printing. The drying apparatus, again, has been greatly improved, and an entirely different method of drying the printed cloth has been introduced in the latest makes of many-colour printing machines. Upon this subject we hope to treat more fully further on. The new process of drying is by means of hot air blast, and is a greatly superior mode to the older—the most delicate colours, as well as the ordinary, being more gently, gradually and evenly dried without deterioration. In certain parts of the following description the two Plates XXII. and XXIII. are to be taken in connection.

A, (Plate XXII.,) *foundation* of machine.

B, the *pit* or sunken portion of floor, extending under from front to back of machine about one foot in depth, to enable the printer to reach the lower rollers, etc., and in which he places his colour tubs for replenishing the colour boxes.

C, the *framework*, or one of the two supporting cast-iron sides of the machine, which is firmly secured at the bottom part, C′ C′, to the foundation by means of powerful bolts and nuts.

D, D, the *twelve arms* of the framework, corresponding to and holding the twelve mandrils, N, N, and printing-rollers, O, O, and their respective colour and lint doctors and colour-boxes and rollers, and fitted with mechanical arrangements for moving the printing-rollers in any direction, and for adjusting the colour-boxes and doctors and their accessories.

E E, *roof framework*, for supporting the various rollers, shafts, etc.

F F, *printing cylinder*, or massive cast iron cylindrical surface, revolvable on an axis carried in a movable centre-piece, such that the cylinder may thereby be raised or lowered to a certain extent.

G G, *crown wheel*, or large toothed or cogged wheel which drives or revolves all the twelve printing rollers, by fitting into the teeth of each of the small cog-wheels, one of which is attached to, or is in the same shaft or axle as, the *mandril* of each roller. The cog-wheel on each roller is not shown in the drawing.

H H, large *cog driving-wheel*, on engine shaft, for driving the drawing apparatus, by means of strap 1—*in other words, for hauling or pulling or guiding the cloth, etc., to and from the machine.*

I I, large *toothed or cogged driving-wheel*, on same *shaft as crown wheel, for conveying power to the latter* from

J J, small *cog driving-wheel*, which is driven from

K K, large *wheel* on support *k*, attached to side of wheel J J, and driven from crank of engine-shaft.

It is thus seen how the power is conveyed from the engine—the machine having a small engine for driving it alone—to the mandrils and printing rollers, the cylinder being revolved or carried round by the pressure of the printing rollers.

N N, the *iron mandrils* or axes or axles of copper printing rollers.

O O, the twelve copper printing *engraved rollers.*

P P, *screws* for adjusting copper rollers.

Q, *wooden roller* for blanket.

R, S, S′ and *e*, small *rollers* for supporting and guiding the *back-grey.*

T, *pulleys*, all on the same shaft, for four straps, two being on each side of machine.

U, two *rollers* for receiving printed cloth and folding it (termed "plaiting") by means of two other small wooden rollers, V, which are "slung" in a frame which swings backwards and forwards by means of an eccentric attached to one of the two arms of the frame—thus throwing the web of cloth into folds as it falls—as shown at W, which is a pile of printed and dried calico.

a and *b* are *small wooden rollers* supporting cloth coming from drying apparatus towards rollers U.

c, the roll of washed and dried *back-grey* cloth—being wound upon an iron axle in an open slot, so that as the roll increases in size the axle rises.

d, *pulley* for strap and *roller* on which rests and revolves the roll of grey cloth.

e, *guide-roller*, mentioned above, for back-grey.

f, *rollers* inside water cistern for running back-grey.

g, apparatus for squeezing back-grey as it leaves washing cistern.

h h, *drying apparatus* for *printed calico*, which consists of a series of steam chests, close to which the cloth passes.

i i, *drying apparatus* for *washed back-grey.*

j j, *apparatus* for *washing back-grey.*

It is evident that our drawing, being a section, gives only one view of the machine, and hence many details of it and its working are not shown. These, however, it is hoped, are sufficiently explained in the text elsewhere, and by aid of other diagrams, so that as correct a knowledge of the machine may be obtained by the careful reader as is possible to obtain without practical experience. The reader is now invited to examine the disposition of the arrows in the drawing, showing the directions in which the cloth, etc., travels when the machine is doing its work. The cylinder, in the first place, is covered,—except, as will be readily seen, a small portion directly above centre,—with an endless web of *blanket*, which runs from roller Q, guided by X, into the machine—*i.e.*, between the iron cylinder and the next web, which is the *back-grey*. This is on the top of the blanket, and passes with it in at X round cylinder and out at X′, and passes on to the washing cylinder. It passes, after washing, through drying apparatus, and then towards roller *c*, where it collects into a roll ready for using again as a back-grey, or for utilising by printing upon it. The *unprinted or white calico* comes from a large tightly wound roll of it on an axle supported on a framing not shown in the drawing. The axle lies in two movable slots, and is weighted down with sufficient pressure that the cloth unrolls tightly and evenly—it being kept tight stretched and smooth by passing between several stretching-bars, as it enters the machine, which it does at X on the top of the back-grey, and thus between the *grey* and the printing rollers. A boy (the "back-tenter"), stands beneath X watching the cloth entering the machine, and with the fingers keeping it in the centre and correcting any "scrimp," or folding of the cloth. The cloth then passes round the cylinder, and so between it and all the twelve printing rollers and their charge of colour, and receives the impression from each roller as it proceeds round the cylinder, until on reaching X′ it has the full twelve-coloured pattern. It then passes onward, as indicated by the arrows, and is dried by passing close to, but not in actual contact with, the steam chests, the back or unprinted side of cloth being that next the surface of chest. Being now dry, the printed calico passes out by rollers *b* and *a*, between the rollers at U, and is folded at W ready to be conveyed away to undergo the next process, which is generally that of steaming or ageing.

How to Work the Printing Machine.

Having now described the main parts of the modern printing machine, it still remains for us to point out in our next chapter briefly how it works.

THE BOAT AND SHIP BUILDER.

OUTLINES OF THE PRINCIPLES AND PRACTICE OF HIS ART.

CHAPTER II.

Explanation of certain Points in connection with the Floating of Bodies.—The Centre of Buoyancy.—Why a Body Floats.

THE reason why one body floats in or upon the water, and another sinks into and down through it, depends wholly upon the relation which the weight of the body has to a certain bulk of the water; and as this relation has of necessity an intimate connection with floating bodies, before the point connected with these bodies named in the title to this paragraph can be understood, it will be necessary here briefly to allude to that principle in hydrostatics or hydraulics which regulates the flotation of bodies in water. In matter which is perfectly fluid, the particles or molecules—the former of those two terms is that applied in practice to fluids, the latter to solids—are so mobile, that however near to each other they may be, they move about amongst each other in all directions freely, and with such facility that they give way or yield to the smallest pressure to which they may be subjected, causing them to change their position relatively to one another. The two fluids with which the mechanic has chiefly, almost wholly, to deal, are air and water; and the great difference between them lies in this: that while air and all gases are in one sense easily compressed or squeezed, so to say, together, so that they can be made to occupy a space or bulk very much less than their normal volume—water is practically so incompressible that in all mechanical investigations the compression is disregarded altogether, and it is taken to be absolutely non-compressible. In the papers treating on the principles of mechanics already alluded to, the reader will find it explained how a pressure acting upon a solid body is exerted in one direction only, or acts only at one point or part of the body, or in single lines of direction only. But it is the special characteristic of a liquid that it gives equality of pressure in all directions; so that if the surface of a body of water be subjected to a pressure or force on any part of that surface, that pressure or force will be transmitted to every particle of the water and in all directions. This property of a liquid, such as water, and which is formulated in the phrase "pressure equal in all directions," is one which carries with it the most practical consideration to the engineer and mechanic, as it influences a very wide range of their work. If, then, any part of the surface of a body of water be pressed upon by a force equal say to one ton, this force will be transmitted through the particles of water constituting the whole body, and will act equally on all parts of the vessel which contains it; and if this was closed at top, the upper part would be submitted to the same pressure, or be resisting it with a force equal to one ton. This equality of pressure on all the surfaces of a vessel containing water, and on part of the surface on which a pressure is exerted, is familiarly, yet clearly illustrated by the domestic appliance known as a water bag or bottle used in cases of sickness. This is made of india-rubber, and from its elasticity admits of the mobility of the particles of the water with which it is nearly filled showing itself very obviously. For if the bag or bottle, while lying on a flat surface, as that of a table, be pressed upon at one part by the fingers or the hand, the upper surface of one part of the bag will be seen to curve upwards, while the end will curve or bulge outwards; and if the bag be moved along the surface till part of it projects beyond the table, part of the surface of the bag will be seen to bulge downwards—this showing that the pressure is transmitted in all directions. And that it was equal in all those, could be easily enough shown by using a given weight to give the pressure, in place of the muscular force of the wrist and hand.

Certain Points connected with the term "Centre of Buoyancy" (*continued*).—The Floating or Flotation of Bodies.

When a body is placed in water and left free, it has a tendency through gravity to drop or sink downwards to the bottom, and this in proportion to its own weight. But as, in accordance with the principle or truth in physics known as "impenetrability," no two bodies can exist in the same space at the same time—when the body finds a place in the water it can only find it by dislodging, or, as the technical term has it, "displacing" some of the water, in order to make room, so to say, for itself. If we suppose that the body was placed upon the top of an elastic substance, such as wool contained in a vessel or box, the body could only find a place amongst or upon the wool by compressing it, or squeezing so much of it together as to give it a place, and the amount of compression would be that due to the weight of the body. But water, as we have seen, is practically incompressible, so that a number of particles which would go to make up a bulk of the same kind or amount as that of the body must be displaced before the body can find a place, so to say, in the general body of water. Thus, let *a b c d*, in fig. 1, be a vessel which contains water—it may represent the cross section of a canal lock—and so full that its level is exactly on a level with the upper edge, as *a d*. Let *e f g h* be a floating body placed or plunged

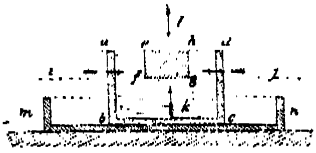


Fig. 1.

into the water, the top line or surface of which is coincident with the line a d of water in the vessel a b c d. Now, as "room must be made for it," to put the point in familiar language, in virtue of the principle of impenetrability above named, it is obvious that just as much water and no more will be displaced from the general body as will be precisely equivalent to the bulk of the body *e f g h.* But as the vessel is quite full up to the very edge *a d*, and as room must in turn be made for the bulk of water displaced, this of necessity flows over the edge. If the body *e f g h* be now taken out of the vessel *a b c d*, in proportion as the body is lifted up so will the water in contact with it be forced back to fill up what was the void—the pressure of the water being equal in all directions—till the point where the body is wholly lifted out, when the water which was around the body is forced into, or flows back into, the space which the body occupied. But while the water in the vessel assumes the level, that level is no longer at the line *a d*, but is at a point, say, represented by the dotted line *i j*, which is just so much lower as the bulk or volume of water now present in the vessel is less than when it was filled up to the level of the edge *a d*, and this volume is precisely the same as the bulk or volume of the body *e f g h*. To prove this we can suppose that when the body was first plunged into the water in *a b c d*, in place of allowing the volume displaced or dislodged by it to run uselessly away and be lost, it had been caught up and retained by another vessel, as *m n*, in which *a b c d* was placed; if the whole of this be now collected and put back again into the vessel *a b c d*, of which the lessened amount or volume gives the level or height at *i j*, the vessel will be again filled, and the level will rise to the original level *a d*. We here presume that care has been taken to collect and return the whole of the water which was "displaced" by the body *e f g h*, and, as the vessel was quite full, was of necessity "dislodged" from it. The student will now see how any body which is placed in or plunged into water displaces a volume of water precisely equal to its own bulk, and if there be room in the vessel holding the water the level of the water will rise just in proportion to the bulk of the body, or if the vessel be full, as much will be dislodged from the vessel and flow away from it as equals that bulk.

Displacement of Water by Bodies floating in it.

All the considerations connected with the point above explained are quite independent of the fact whether the body remains or is suspended, so to say, in the position as in fig. 1, or whether it sinks lower towards the bottom, or rises up or "floats higher" in the water. But if the point be further pursued, the young reader may see the reason why one body sinks in water till it reaches the bottom, or sinks so far that it is submerged or covered with a certain depth of water above it; while another body does not sink, but is supported, to use the popular phrase, by the water, and "floats" upon the surface, or more correctly, sinks so far into the water that part of the depth of the body is submerged below the surface or general level of the water. Previous to the body *e f g h*, fig. 1, being placed in the water, the volume of water it was about to displace, and which volume is obviously represented by the same bulk—namely, *e f g h*—must also, and obviously, have been supported or held up by the presence of the water acting upwards in the direction of the arrow *k* on the line *f g*, which we can suppose to be the base or bottom of the bulk or volume of water *e f g h*. This the young reader will see must be so if he remembers what has been said of pressure acting equally in all directions in a body of water. And still conceiving a volume or bulk of water, as *e f g h*, to be as it were distinct from the general mass, it will be pressed equally in the direction of the right-hand arrow on the side *g h*, as it is pressed in the direction of the left-hand arrow on the side *f e*, and as it is pressed upwards in that of the arrow *k*, and being thus pressed equally on all sides, the volume rests quiescent in the position as at *e f g h*. Now, keeping in mind the fact of the upward pressure acting on *f g* in the direction of the arrow *k* as holding, forcing or pressing up the bulk or volume of water represented by *e f g h*,—if the student will now conceive this bulk to be taken up and occupied by a floating body of the same bulk or volume *e f g h*, it is obvious that *its* lower side, as *f g*, and its right and left end-sides *e f, g h*, will be acted upon by the water in the direction of the arrow *k* and those near the sides, *i* and *j*, just as in the case cited above, where we supposed the bulk *e f g h* to be water. The point here stated is one of such importance in all questions connected with the science of hydrostatics as affecting bodies or vessels placed in and floating on water, that it will be well still further to go into its consideration. Take any body or mass of water enclosed, whether it be by the banks of a river, the walls of a dock, or the sides of a canal lock, in the large, or in a vessel of no great dimensions in the small scale. Let us conceive of this body or mass of water as being made up of a series of hexagonal columns, which from their sectional outline or form will lie closely together without any intervening space, the enclosing sides being finished with half-hexagons and the voids filled so as to form the whole surface of hexagons. The height of these hexagonal columns is equal to the depth of the mass of water or its height from base to level line at top of enclosing space. If we conceive of those columns being infinitely small in section, all of the same height and all vertical, the surface of the water will be level and quiescent—that is, when not subjected to any exterior force, as that of wind, tending to disturb that level and raise one part above the surface of another part. And being thus perfectly quiescent in the conditions above named, the columns as a whole must be in a balanced condition, or, to use the technical expression, *in equilibrio.* If we further conceive every one of the hexagonal columns to be cut across at certain definite intervals of its height, we have a series, so to say, of discs of definite thickness, the whole height of the column being made up of a series of those discs, each one resting upon another, the last one at the foot of the column resting upon the bottom of the dock, canal lock, or river bed, or base of containing vessel, and exerting thereon a certain pressure. It is obvious that the amount of this pressure is determined by the number of the discs—that is, by the height of the column. We only make this remark in passing, as it refers to another branch of hydraulic engineering; we have at present to concern ourselves with the relation which one disc has to another in the same columns, and that which this bears to the other columns surrounding it. If we suppose the column to be represented by the arrow *k*, in fig. 1 (*ante*), a disc at any point in its height between the bottom and the top—as, say, at a point coincident with the line *i j*—possessing as it does a certain weight of water, has a tendency, if not supported, to drop or fall down vertically in the direction of the arrow *l*. But the disc cannot drop, because it is supported by a disc immediately below it; and this lower disc—as indeed and of necessity the upper disc in our supposed case—is kept pressed or pressing up in its effort, so to express it, to escape from the pressures which are being exerted on all sides of it, as in the direction of the horizontal arrows *i* and *j*, fig. 1, and the vertical arrow *k*. The same holds true of any other column; and all being under precisely the same conditions, the result is that the whole remain in a state of balance or equilibrium—that is, supposing that no exterior disturbing force is exerted on the mass of them.

Displacement of Water by Bodies floating in it (*continued*).

And by enlarging our conception of the size or section of the hexagonal columns, we may arrive at the idea of one of them so large as to weigh, say, one pound. Now, in this case it is evident that the bulk of the disc would be, could be, no other in weight than one pound. And giving to this bulk the technical name used in relation to this part of the science of hydrostatics—namely, "volume"—we should have the disc of a volume equal to the weight of a pound of water; and the pressure of the disc immediately under it—that is, the disc having also a weight and a volume equal to the weight of one pound—would press upwards with the weight of, or the pressure corresponding to, a pound. And if we conceive the place of the disc of water to be occupied by a disc of wood, the volume or bulk of the wood would be exactly the same as that of the disc of water it "displaced." And the conditions as to pressure would be precisely the same. In this case we should say that the disc of wood which took the place of—or, to use the technical term, displaced—the disc of water represented a volume equal to its weight, or *vice versâ*. Nor would the condition be altered if we suppose that the disc, say of an inch in thickness or height, considered in relation to the vertical column of which it formed a part, was composed of two materials, half an inch being of wood and half of cork: although the one half might be twice as heavy as the other, the bulk or volume would still be the same as that of the disc of water which it displaced, and thus the conditions would be as before: the volume or bulk in all these cases being the dominant consideration, and this regulating the weight, and therefore the pressure, of water which this volume represented.

Further Considerations connected with the Displacement of Water by Bodies floating in it.

Bearing in mind what has been said as to pressure of water being equal in all directions, and in relation to the case represented by fig. 1 (*ante*), the fact that the upward pressure acts on *f g* in the direction of the arrow *k*, holding, forcing, or pressing up and supporting the bulk or volume of *water*, which may be considered as sender up of a number of the discs referred to in the last two paragraphs, represented by *e f g h*,—if the reader will now conceive this bulk to be taken up and occupied by another body of a different character, say a solid, which floats at the same level, he will see that the same pressure as represented by the upward-pointing arrow *k* forces, holds up, or presses upon the solid body and prevents it from sinking. We have seen that the bulk of water displaced by this body is equal to its own bulk. Now, the force represented by the vertical arrow *k*, holding up the solid body, is *equal*—as it is also *opposite*—*to the weight of the volume of displaced water.* Thus, if the volume of water displaced from the vessel *a b c d* in fig. 1, and caught up by and retained in the vessel *m n*, be taken and weighed, and then the solid body *e f g h* which, be it remembered, floats in the position *e f g h*—be taken and also weighed, the weight of the one will be found exactly equal to the other—that is, on the supposition that *all* the water displaced from *a b c d* be taken from the vessel *k l*. If the weight of the displaced water be less than that of the body, the difference shows the weight or quantity of water lost, or such as may be supposed to be lost, by some of the displaced water adhering to the sides or surfaces of the vessels. Bearing this truth in mind, which we have italicised above, we now see how it affects the question of a body either sinking down into and through the water, or "floating" near its surface. The upward pressure represented by the up pointing vertical arrow *k* in fig. 1 is always equal to the weight of the volume of water displaced by the body, and while the bulk of the body, as *e f g h*, remains constant, the pressure upwards, represented by the arrow *k*, will also be constant, for that pressure is equal to the weight of the volume of water displaced, and that volume is the same as is regulated by the bulk of the body which displaces it.

Relation of the Weight of Floating Bodies to the Volume of Water they displace.—The Burden or Tonnage of Ships.

We have just explained, by means of the illustration in fig. 1, that the weight of water displaced by a body floating in it must always be equal to the weight of that body, and that the pressure of the water acting upwards, as in the direction of the arrow *k*, fig. 1, must be equal to the weight of the water displaced by the floating body: it follows also, as a matter of course, that if that body be weighted—that is, be made to carry a small load—an amount of water will be displaced equal to the amount of load extra, or in addition to that which in its original condition it displaced. Thus, suppose the vessel *a b c d*, fig. 1, be filled with water quite up to the level of top *a d*. Now immerse gently the body *e f g h*, which suppose to be a block of wood of such gravity that it floats as shown. As the body or block gets immersed and floats, the water runs over the edge, *a d*, of the vessel *a b c d*, and is caught up and retained by the vessel *m n*, in which it stands. We have shown that the weight of the water displaced from *a b c d* and caught up in *m n* is, allowing for waste water adhering to the surfaces of the two vessels, precisely the same as the weight of the body *e f g h*. After weighing the body replace it in the water in *a b c d*, and it will float in the same position as before, with the water line at *a d*. Place some small weights on the top, *e h*, of the block *e f g h*, and the water will flow over the edge, displaced by the greater weight, and be caught up by the vessel *m n*. Presuming that the water at first displaced by the simple block *e f g h*, and which was taken out of the vessel *m n* and weighed, has been retained in the vessel in which it was weighed, and which is large enough to contain more than this—weigh now the second portion of water caught up in *m n*, and then pour it into the large vessel. It will be found that the united weight of the two portions of displaced water will be precisely equal to the block *e f g h* with its load of small weights, if the two be taken out and weighed. Here we have a condition of matters in which we can on the one hand calculate the exact weight of the body *e f g h* with its load, by weighing the water which it displaces, or we can conveniently tell or calculate the weight of water displaced by a given floating body if we know the weight of that body. The relation of the facts we have now stated to the department of mechanics known as "specific gravity," by which the different weights or densities of differing bodies or substances are ascertained in relation to a certain standard, will be found in its proper place fully explained in the series of papers in this Journal entitled "The Technical Student's Introduction to the Principles of Mechanics." What we have now to concern ourselves with is their relation to the technical points connected with floating bodies, as boats and ships. Our young readers must have frequently come across the expression "ship's burden" (often spelt "burthen"), or tonnage of ships, a term indicating that they can carry safely goods or weights of so many tons in amount. The relation of the illustration just given to this subject will now appear obvious. For, as we now know every addition to the load of a floating body adds to the displacement of water, and to the weight of this, we have a means of ascertaining what a given ship will carry, for everything on "board of her," to use the technical nautical phrase, as it possesses weight, displaces a definite and equal weight of water. And we have therefore only to calculate the displacement due to her immersion, or floating line, and express this in cubic feet, and multiply the number of feet by the weight of a cubic foot of water, to find the total displacement—which of course gives the equivalent for the weight of the vessel and its load. It is a comparatively easy thing to calculate the displacement of a floating body or vessel of regular outline, such as that at *e f g h*, the length and depth of which are at *f g*, and *e f* or *h g*, and the breadth of which is known; for obviously the volume of water displaced is just that occupied by this solid parallelopipedon or rectangular prism, the cubic contents or bulk of which it is a very easy matter to compute. The case is different with a boat or ship, the "lines" of which, as even the youngest of our readers know, vary very much, and give to the solid body a very complicated form to estimate the cubic contents of. Nevertheless, although this is not practically done with definite precision, approximative calculations are made with such a near approach to the actual displacement that this approximation can be relied upon for all practical purposes. The subject is here only opened up, or rather incidentally referred to, as a practical illustration of the facts we have stated as to the displacement of water by floating bodies; but we have yet much to give concerning it at a future and appropriate part of our series of papers.

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER I.

Introductory.—The Steam Engine universally employed as a Prime Mover.

THIS is not the place, nor does it enter into the scheme of the present series of papers, to give precise and more lengthy or exhaustive details as to the history of the steam engine. These find a more fitting place in the pages of special treatises, which can consistently give the space which is necessary to do fair justice to the important, at least mechanically interesting, points connected with the rise and progress of this great invention, which has quite revolutionised the conditions of the community, so far as the giving of a new power competent to perform vast labours in fields as wide as they are diverse in character, and in locomotion of land and sea, is concerned. Neither does it fall within our province here to refer in general terms to, or in special instances to quote from, the elegant and eloquent eulogies which have been given from time to time on the steam engine and what it has done for man. As in the case of our national architect those who wish to see his monument are invited to look around at the general magnificence of St. Paul's Cathedral, which owes its existence to his daring genius, so in the case of the steam engine we have but to look around to see examples of its endless and varied forms, and of the work it has done for us existing everywhere and always. But extensively as it is used wherever power is to be created for the doing of any definite work, it was for long confined chiefly to doing the work of our factories and workshops, to propelling the steamboat or to dragging the railway train. But later years have witnessed its introduction into quiet rural districts which at one time seemed to be quite free from any chance of its invading their great fields. And taken up by the farmer, we see that he applies it in substitution for the animal power on which we were long dependent; and by its aid not merely threshes out his corn or grain for market, cuts the hay and straw, slices the turnips, and crushes the grain or the oilcake he requires for his live stock; but goes out with it into his fields, and with it ploughs his land for crops, which before long he hopes to cut and reap by its means.

New Views as to the Likelihood of the Steam Engine being speedily superseded by other and better forms of Prime Movers.

But universally as it used, and firm a hold as it has taken on the minds of men as the best, most untiring and economical motive power, it is worthy of special note here, as one of the signs of incessant mechanical activity which mark the times we live in, that some—and of these a few high as engineering authorities—have pronounced the steam engine to be wasteful in working, and in view of more economical motors have in fact pronounced sentence of death upon it—a sentence which they think is to be so speedily executed, that before long the steam engine in its present form will be a thing of the past, and its place taken by a motor or by motors simple in construction, infinitely more easy in management, and vastly more economical in operation. If this view be correct, it would seem as if the purpose our papers are designed to secure would have but a limited period in which it could be of practical service—that the space they take up would be better occupied by explaining the characteristics and holding up the working of those motors which are designed to take the place of the present steam engine. But although this will be done, inasmuch as it is necessary for the aim and objects of our Journal to do it, the reader may rest assured that, in spite of the sanguine vaticinations of some of our engineers, it is not the present generation, and if the signs be read aright which are open to us, possibly not the next, or even the generation succeeding that, which will see the steam engine so universally superseded as to make a paper of this kind no longer a necessity.

The Likelihood, almost Certainty, that the Steam Engine will, for a long time to come, be the generally employed Prime Mover.—The Electric Engine as its Rival and Supplanter.

In view, indeed, of the characteristic features which *per se* the steam engine in its accepted forms possesses, the singularly happy relation it occupies as to our coal supplies—obtainable at every hand, and at wonderfully cheap rates—the comparative simplicity of its parts, the ease with which, even in ignorant hands, it can be worked and controlled, the truth would rather seem to be that the steam engine in place of being superseded wholly by other kinds of prime motors, as the gas engine, which at present seems to be the rival of its future, will remain for many years—possibly many generations—in its present position of *the* prime mover for all our industrial processes. This does not preclude, but rather presupposes that improvements in the engine—to say nothing at present of the boiler—will be made, and of a character calculated to make it more efficient, and certainly more economical in its working, than it is now. This improvement indeed follows almost as a matter of business necessity. For the faults which are found with it, and the charges made against it by those who have taken up the position that it is already doomed to become speedily extinct, will act as the most powerful incentives to those who still believe that it is the best prime mover we can, under all our natural and local circumstances, possess, to do all in their power to make it still more efficient, and thus to justify their good opinion of it.

Assuredly there are but few signs, if indeed there be a single one, around us which would indicate in any marked and special way that the steam engine is doomed to anything like a speedy extinction, or even that it will be to any appreciable extent superseded by some other form of prime mover, such as the gas engine. This by no means lessens the value of such prime movers as may be said to be new claimants for the patronage of those who require motive power for one or other of the extensive range of purposes in which mechanical work is to be done. In the proper place we shall not be slow to point out or acknowledge the advantages which such new prime movers as the gas engine possess; meanwhile, concerned as we are here with the great machine which at present far outnumbers them, we are simply taking what appears to be but a common-sense view of the position of affairs in regard to the relation which subsists between the steam engine as a prime mover, and the natural and local circumstances which make it so admirably suited to take the best, the quickest, and, upon the whole, the most economical advantage of these. In the history of mechanical or physical science, it it is not difficult to find examples of what may be called "scares,"—to use a phrase so largely used nowadays as to make its meaning as applied here well understood. Every now and then machines or processes which are well, and some of which have been for a long time established, are threatened with quick and complete extinction by some new machine or process, which is said to be so good as to preclude all hope that anything will ever be found which can be better. In these sanguine views which the supporters of those new things hold, they quite ignore the fact that they are certain to possess the same character of imperfection which belongs to all the works of man; and which imperfection they so loudly call attention to in the machines or processes which their new things are, as they say, so thoroughly competent to supersede. We have had of late some rather striking examples of this tendency, in the inventors and discoverers or promoters of new machines and processes. Some short time ago we were told pretty confidently that the days of gas lighting were numbered, and that gas works, with all their costly and complicated apparatus and appliances, would cease to exist. The new process of electric lighting was to do all this and more, if some of its enthusiastic supporters were to be credited. Shareholders in gas companies who had overlooked all that the experience of humanity had taught them rushed off to sell their "stock," and in many cases to re-invest in those companies which sprang up, mushroom like, to promote the introduction of the new light. Such would have made greater speed had they taken more leisure to consider in what direction they were so eager to go. Those who took a more common-sense, and it may safely be said a more scientific view of the position at the time and the possibilities of the future of the old light and the new, concluded that the probabilities were not very great, to say the most, that the new would speedily and so completely supplant the old, as to make the vast works connected with the old light obsolete and useless. And a similar scare, so still to call it, arose at the same time, and through the same cause, in the matter of the steam engine, which was very quickly, according to not a few, and most completely, to be "put out of court" as useless, by the newer and more brilliant power of electricity. The electric engine, according to such authorities, was to be everywhere, the steam engine nowhere. It mattered little to some—though with other and clearer minds the point told with effect—to have their attention drawn to the fact that, in view of all the wonders which electricity was to perform in the way of giving a motive power to man, it was, to put the matter very mildly, somewhat strange that before it could give us the "electric light," which also was to do such great things in the gas-lighting question, it was somehow compelled to borrow the help of the much despised steam engine to work the dynamos or apparatus by which the electricity was so to say created—and which was yet, somehow, at the same time to supersede the necessity of having any steam engines at work at all. The point here involved does not in the very slightest degree detract from the high value possessed by the power of developed electricity, nor from the marvels which that power has even now created. Great as those have been in the past, we are of those who believe that they will be eclipsed by the still greater marvels of the future. For it is difficult to set bounds to, or even to conceive the potentialities of, electricity as a help to man in the doing of his work or in ministering to the comforts and the elegances of existence. But beyond any doubt or cavil, those potentialities have yet to wait for their practical existence for some method quite different from that at present used, where we are compelled to employ some other power to give us supplies of the "wondrous thing" to which we give the name of electricity. It seems, for aught we know, to exist everywhere, to be present in all matter; and the day may yet dawn which will give to man the ability to get supplies of it as readily and easily available for the production of motive power as are the supplies of coal and water, which, used in and by appropriate appliances and machines, give us the motive power we call the steam engine. Till then the steam engine has little to fear from electricity supplies of which are obtained in the way—or in like fashion in which they are secured at present: that is, by the employment of some other power, as, for example, the steam engine, which notwithstanding is, according to some, to be supplemented by the electric engine.

The Subject of Last Paragraph continued.—The Future of the Steam Engine.—The Gas Engine as its Rival and Supplanter.

The case as it stands is somewhat different when we take into consideration the gas engine as a rival to the steam engine. We are disposed to go far with, nearly as far as, those who believe that the gas engine is to be the prime mover of the future. No one, indeed, who has had even but a comparatively slight acquaintance with what has been done of late, we might say recent, years, in the science of thermodynamics—or, to give it a more popular name, heat power or motions—can hesitate in believing that we are on the threshold of some decided changes in the way we avail ourselves of the heat stored up in our coal supplies. That we have in past times thrown, and for the matter of that are throwing away daily, a huge proportion of the heat which coal can give us, is beyond any doubt. And those who know what the comparatively modern invention known as the "gas producer" (see the series of papers in the Journal which will yet be published under the title of "The Furnace Builder") has done in the hands of such gifted men as the late Sir Charles Siemens, and a host of able workers who followed in his steps, in the way of using coal economically, so as to get out of it the largest percentage of heat it is capable of bestowing, must have had the conviction forced upon them that we shall in the future make a more sensible, because a more scientific use of the stores of coal which a beneficent God has given us naturally in such large abundance. And those who may think so little of the folly and the sin of "waste" as to be careless in the matter of adopting any improved and more scientific way of using coal simply because it avoids this waste, may take quite another view of the matter when they find out that such methods not only avoid waste—to them at the best but a negative advantage—but will give them the positive benefit of getting their work better and more cheaply done under the new mode than under the old. What inflammable gases can do in the way of saving the consumption of vast quantities of coal is witnessed with striking effect in our iron districts. There in many instances the steam is raised, or hot blasts obtained, without the consumption of a single pound of coal; and this, be it noted, by the use of those very gases which were truly called "waste," and which years ago were passed uselessly into the air from our iron blast furnaces. We go far, therefore, with those who see a wide future for the gas engine, and this more and more extending as the knowledge of the right way of consuming coal becomes diffused amongst those who are large users of motive powers. But we do not go so far as some, who persist in stating that the steam engine is doomed, and that it will be wholly, and as some say also quickly, supplemented by the gas engine. And in saying this we by no means ignore the scientific and mechanical industrial value of the gas engine,—we are ready to join in its praises to the utmost point,—but it is because we judge that the evidences around us in favour of its quickly and wholly supplanting the steam engine are not sufficiently abundant to justify the belief that this will be so.

Some Practical Business Considerations connected with the Foregoing, as to the Future of the Steam Engine.

If we look at the point simply from an everyday, ordinary, or what may be called the common-sense point of view, we shall see quite enough to convince us that to supplant such a long used and so firmly an established machine as the steam engine is not quite the easy thing it is said by some to be. The mere conservatism of human nature is strongly against this conclusion. Just as it is difficult to get men, accustomed for long to go in one groove or line of action, to move into another and quite a new one, when old and thoroughly established habits are to be overcome, and possibly (nay, very probably) a host of prejudices to be removed,—so it is difficult to get men to move as a body in getting rid of any particular kind of mechanical help which has for long assuredly served them in good stead in the doing of a wide variety of work, and to take up a new kind, however promising it may be. Nor will the fact that the old mechanical aid may be proved, beyond even the possibility of doubt or cavil, to be wasteful, and therefore unnecessarily costly in working, and the new one just as conclusively proved to be as economical, prove so powerful an incentive for parties widely to make the exchange, as some hold it is, on the ground that self-interest, the claims of the purse, which are said always to be clamorous, will be so powerful that the exchange will be quickly and universally made. The fact, as we find it existing amongst us in the everyday walks of life, is much more the other way, and proves that self-interest, strong as it is with some, is much exceeded in strength with more, by pure prejudice, or the constraining force of long-continued habit. And that this is so can be easily proved any day, everywhere, and always, in every class of technical workers. If it were not so, inventors of new mechanical arrangements, discoverers of new processes, would, in place of having to wait wearily and long, as they generally have ever had, and still have to do, to get their new things introduced and widely supplant the old, they would be quickly overwhelmed with orders to begin and complete at once the transference or transformation. We could cite cases almost endless in number in support of this; but suffice it to take here one instance, and that a recent one. The researches and the results of patient practical working of such men as Siemens have proved beyond any doubt that by the adoption of new and soundly scientific methods of effecting fuel or coal combustion, a saving as compared with the results of the old methods would be effected, which, taking into consideration the almost universal directions in which the new methods could be used in connection with all our industrial processes where fuel combustion is a necessity, would be so enormous that we may write or name the amount in figures and yet have no mental conception of its value. The difficulty is, not to prove the value of the new method, but to get men practically to believe it. All, or nearly all, are quite ready to give an intellectual assent to it; few attempt to confute its theory, or dare to deny the facts of its practice. But this merely mental assent to or agreement with the new theory goes no further with the majority; and if self-interest alone had had to decide the point, by this time, after all that has been done to prove the high value of the new systems of fuel combustion, the old methods ought to have been nearly, or altogether, obsolete. But nothing of the kind has happened, and the adaptations of the new are but as units while the old methods can be reckoned by thousands; and there is not much evidence to be had to prove that it will be otherwise for a long time to come. Nor, after all, need this be matter of great surprise, when we consider that there are purely business points mixed up with all questions concerning the adoption of new for the supplanting of old machines or of long established processes. The old machines and appliances are there; they have been erected and put down at greater or less cost; they have been paid for; they have, beyond all dispute, done good work—have given their users fair, if not in many cases very handsome profits; and before they can be supplanted by other and newer things, they have to be taken down if the space they occupy is valuable, or left standing if it can be spared; but in any case rendered useless. And to one who, for example, has a mill or a floor full of machines which have cost him much hard cash, it requires very long and careful cogitation on his part, and will at the best cause him a pang more or less painful, to see them taken out, carted off, and sold as old iron—as many a mill full of machinery has been sold—and their place taken by new machines, which have in turn to be paid for. And some appliances, such as those connected with the iron manufacture (see the paper entitled "The Iron Worker" in this Journal), are so very costly that their owners are scarcely to be blamed for thinking twice before they supplant them with newer forms, however more economical in working and effective they may be proved beyond all doubt to be. The marvel rather would seem to be that, seeing the enormous cost and trouble involved in getting rid of old machines and processes to make way for new ones, so many of our technical manufacturers do go through the costly process with such apparent indifference. That they do even in these comparatively few cases, speaks volumes for the enterprise of those connected with our trades and manufactures. But the fact that those cases are exceptional proves abundantly the truth of our position, and affords a powerful argument in favour of the view held by the great majority that it will be long before the steam engine is supplanted by other forms of prime movers which are said, or even proved beyond a doubt, to be better and more economical than it. And we have purposely put before our youthful technical readers the foregoing considerations, inasmuch as it is important that in early life they should form the habit of looking at a subject from more than one point of view, however brilliant and fascinating that point may be—looking at it, in fact, as the saying is, all round. Nor, moreover, are the considerations we have given likely to be useless to our youthful readers when they get on in years and forward in position. They are reasonably looking forward now to the time when they will be masters then; and if they reach this point, then it will be found that they have a very close bearing indeed on the way in which their "business" is conducted and their success in life secured.

Importance of a Knowledge of the Steam Engine, its Principles and Details, to the Steam Engine User and Driver.

Let us then take it for granted that the steam engine will be for a long time the almost universally employed prime or first mover, where power to do mechanical work is required. On leaving the field of controversy which this assumption may open up, to some, and adverting only to the fact, which no one can venture to dispute, that at all events the steam engine is now or at present the almost universally employed prime mover, it is scarcely necessary to take up much, if indeed any, space in proving the advantages which will flow to the user of a steam engine or to its driver, by having a knowledge of its principles and its details, and how these can be made most effective in the doing of the work demanded of it. This is so obvious that all that it seems necessary to give in support of it, is the old saying, that the more you know of a thing the better you can use it. Let us look for a brief space, say at the case of the users and drivers of the class of steam engines known as portable, employed now all over the world in a wonderfully wide range of industrial work. It is a *complaint —we regret to say but too well founded upon experience*—somewhat frequently formulated by engineers and machinists, that their engines and machines have not "fair play," as the phrase goes. Put in another but more periphrastic form, this means that the engines and machines they furnish to their customers are not always—indeed, as some have a special right to complain, not often—either kept carefully in good working order as when left with them, or so maintained by careful working and judicious management. No doubt it may be said, and truly enough, that the objections made to, and faults found with, both the arrangement and the style of working of their machines and engines have their origin not with the carelessness of their customers personally, but with the men they employ to take charge of them. But though this is perhaps true as a rule, still it may without any breach of justice be said that customers or masters are in many cases the true cause of the difficulties here alluded to arising; for they have at least the power to insist upon those in their employ working the engines and machines carefully and using them judiciously—and if they do not exercise this, it is not easy to say that they are blameless in the matter. No doubt it may be said that they are not themselves acquainted with what is careful usage or judicious working; that they are not, in brief, engineers or machinists, that they should be expected to know these things. This is specially true of the class who use agricultural portable engines as part of the machinery of their daily farm work. Still even those who can plead mechanical ignorance cannot plead that they do not know how to treat property with care. And it not seldom is seen that on the farm there is a positively wanton indifference to the condition in which valuable machinery is kept and the way in which it is treated. The writer of these lines has had occasion in business to have much to do with machinery employed out of doors, and in the out-of-the-way places in which portable engines are worked; and he has frequently been really concerned to note the waste which goes on in connection with this—a waste which could be easily avoided, and that without requiring any mechanical knowledge, only the exercise of that common-sense care which surely no one can deny the ability to possess. It takes, for example, no mechanical knowledge to be aware of the effect of moisture upon iron and steel work, or of exposure to atmospheric influences; no great knowledge to be aware of the effects of accumulated dirt; and although perhaps a little more, still not much, mechanical knowledge to know that parts of the engine working loose, joints of steam pipes, etc., etc., leaking, are just so many evidences of waste of power. Yet, in these and in other ways, many a portable steam engine which was *originally turned out a good machine of its class by the maker, is allowed but too rapidly to get out of order, for which the maker is not seldom* blamed. There are of course other points connected with steam engine management which demand a higher class of mechanical knowledge and of these the present paper will in due course inform the reader. This brings us to the

General Plan of the Present Series of Papers.

Although we have but just named the class of steam engines known as "portable," which, while it embraces high-class work both in design and detail, may be taken as a whole as giving our simplest forms of engines, still our readers must not suppose that our remarks are meant to apply solely to this class, or to engines of corresponding size which are designed to give out power only to a limited extent, as in the case of small works or factories, or where but a single, and comparatively a simple, train of machines is to be worked. We hope to be able to present the readers of our papers with much that will be practically valuable in cases where the steam-engine power is comparatively and also positively large. There are more ways than one of treating our subject. We might, for example, begin by giving a general view of the steam engine, and explain briefly the principles of its action. Thereafter we might go into a description of its details, and at that stage give remarks upon modes of fitting the parts up, and of putting them and keeping them in good working order and repair, and the details of its general management. And finally we might explain the methods by which the condition of the engine was ascertained, and whether it was giving out its most effective power, and if not, what were its defects—in other words, the cause of loss of power, which means practically waste of fuel. After, however, taking into consideration the circumstances connected with the varied class of readers, and looking at the larger amount of practical interest which is likely at first to be created in the subject, we have determined to reverse the order of the arrangement just named. This brings us at once to deal with the last-named point; and in connection with it we have to draw attention to the value of the "indicator" to users of steam-engine power.

The Indicator an Instrument Essential in ascertaining the True Character, defective or otherwise, of the Work done, and the Effective Power given out by a Steam Engine.

Although now used to a very much greater extent than formerly, still its employment is by no means so general as it ought to be, even amongst those who know its value; while not a few are to be met with who know but little concerning it, and that little not always accurate.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER IV.

The Theories of Mechanics generally accepted by Scientific Men, so accepted because they fit well in with and afford a Convenient or Reasonable Method of studying Natural Phenomena and applying those to Practical Work.

AND this is so, not that the men of science know, or even profess to know, *all* about the phenomena, or pretend to say that their definitions of certain terms are absolutely correct: they merely accept them—and we can affirm that they constitute the great majority —for the reason stated in preceding paragraph. And they are in the fullest sense justified in so accepting them, inasmuch as they can assert with no small degree of pardonable pride that all the gigantic and varied works of our modern engineers and mechanics have been worked out upon the lines or in connection with such devices. In what we deem it necessary to give, therefore, on the theory of mechanics, we purpose to go upon the lines and to follow upon the principles about which the great majority of scientific and practical men are fully agreed: principles which make up a theory of mechanics which fits in, on the whole, so admirably, and it may be said so logically or reasonably, with the facts of daily experience, that by its help men have been enabled to bring into existence all the wide range of mechanical helps in the doing of man's works which we see around us. And what has enabled mechanics and engineers as a body to do so much practical work may well decide the youthful reader who purposes to follow during his after life in their steps to conclude that the theory which has suited them may well suit him,—better than one or other of the theories which make demands upon his belief which he instinctively feels that if it is not impossible, yet it is very difficult, for him to believe. And then this other, and the very commonsense consideration, is sure to come up in the mind of, or at least should not be lost sight of by the student—namely, seeing that there are so many theories, or so many explanations or hypotheses, and all of them difficult, which of them is he to believe and accept as his theory? It may be that one is correct, but which is *the one* is a question which, seeing that it is impossible to answer satisfactorily, may well decide the student to rest satisfied with the principles upon which all that mechanics have hitherto done, and are in fact daily doing, depends. For the present at least we counsel the youthful student not to venture a voyage, so to say, upon the sea of scientific theories, conjectures, or mere guesses—the waters of which are not always calm, but somewhat frequently disturbed by winds and waves of discussions which in their warmth are not always consistent with the spirit in which scientific discussions should be carried on.

The Terms used in connection with the Explanations or Description of the Laws on which Natural Phenomena depend —the Basis of what is called the Science of Mechanics.

In giving what we deem it necessary for the youthful student in mechanics to know upon the "old lines" we have indicated, we shall endeavour, in giving the terms necessary to our remarks, to explain clearly what those terms are—that is, what they mean. This is necessary, for we do not write for those who know and could easily explain what they know better than we do: we write for those who do not know the subject. The very fact that they wish to know what we write in order to learn is proof that it is our duty to teach. Now, a teacher should never assume that his pupils know what he knows or ought to know. In explaining terms, then, we purpose in all cases to give their roots —that is, to show what words they are derived from. As a rule, all our scientific terms are derived from the Greek or the Latin, or what we call the classica languages; sometimes from the French directly, sometimes, though but rarely, from the German; and the French words are themselves in many instances derived from the Latin. And this purpose of giving derivations of terms we have decided upon, having a profound belief, derived from a fairly wide experience of what both working men and students are, that those derivations, at least in many instances, throw a clear and full light even upon the principles of which the terms have been adopted for a name; and in al other cases they help at all events to make the student better acquainted with the subject, and with the "real value of words," than without their derivations he would be. On this point we do not require to say more, inasmuch as the subject is gone into with that fulness which its importance assuredly deserves in the Preliminary Dissertation to the "Dictionary of Technical and Trade Terms," which the editor has, in what the writer of those lines feels to be thoroughly in the interests of technical education, determined to form an important part of this Journal. Only this requires to be remarked here: that it may be by some thought that in defining the "terms" of the science of mechanics in this present paper we shall be simply repeating what may be found in the appropriate section of the "Dictionary." To which it is only necessary to reply that what we give here will be sufficiently full, and no more, for our special purposes; the more complete and full definition being found in the "Dictionary." Further, should there be—as in a limited sense it may be truly said that there is—somewhat of a repetition, we think that repetition directly useful in this paper, inasmuch as the reader will find what we give as to the meaning of terms most conveniently placed in relation to the matter being discussed, so that he is not called upon to interrupt the continuity of his reading by turning to the "Dictionary" to know what the meanings of the terms are. This consideration would alone justify a repetition of definitions, even had that been given as fully as we have shown that it is not. For that fulness reference must be made to the "Dictionary."

Certain Terms continually recurring in all Disquisitions on "Mechanics" or Descriptions of Mechanical Work.

In the foregoing paragraphs in this and in the preceding chapters, while glancing at certain points connected with the subject of mechanism, and that in the most general of ways, as purely introductory to the specific disquisitions now about to be commenced, it was impossible to proceed without using certain terms; and of those the reader would not fail to observe that two came up for frequent usage, these being *Motion* and *Force*. We have said that we purposed founding our remarks upon the principles or laws upon which all mechanical work is based in what we have called the natural sequence of subjects, or what appears to us to be so. Now, we cannot conceive of any arrangement of mechanical parts, however simple or complicated those may be, doing what we call "work" without movement of some of these parts, or taking it as a whole, without the machine being in motion. On the other hand, it is just as difficult to conceive how this motion can exist unless it be produced by some cause or another. To that cause which produces the effect of the motion which always accompanies or in fact does the work, the name *force* has been given. To the consideration of these two terms, then, we now direct the attention of the reader—taking that of force first, in accordance with the natural sequence of the subject, it being the cause which produces the effect, that is of motion.

"Force," one of the Terms so frequently used in Mechanical Disquisitions, and referred to in Preceding Paragraph.—Points connected with the Term.

The definition of force has given rise to discussions which have for long time occupied the attention of scientific men, and will apparently, from all we see, continue to do so for long time to come. And judging from the variety of opinions held concerning it, and of the like or a greater number of definitions resulting from those, it seems to be one of those things which no fellow can understand. Nor is this discussion less marked than are other subjects of scientific discussion, if not with the warmth of personality which begets expressions which surely in cooler moments must be regretted, at least certainly with a dogmatism which might well be spared. In connection with which discussion, it appears to us that the paradoxical yet suggestive phrase, "More would be said if less were said," might well and reasonably be applied. And certainly it is unfortunate for at least the student of the principles of mechanics who is about to begin his work of practical study, to meet at the very threshold of his career of thought such a diversity of opinion as to what that is to which common sense tells him he owes the working existence of the machines he makes, and which he knows is exemplified in every bodily exertion he makes or in every physical work to which he sets his hand. No matter from what source he derives it, and no matter whether he calls it a force or power or energy, (this last-named term is here given with a reservation as to its restricted character which will be fully explained further on,) he knows that beyond all doubt, without this something called "force" he could not even make them. Force or power or energy he knows to be present, and to be the cause of the work done, in every stroke of his hammer, in every chip which his chisel makes, in every turn of a screw or a nut; that he cannot even grasp his tool in hand, or make some mechanical contrivance hold his work for him, without this "something." And unfortunate as we deem it to be that the reader should be met at the very outset of his study with discussions all too warmly and keenly maintained—holding, as we do, that the result is, at least at this stage of his career, most puzzling, and what is worse, disheartening—we do not deem it necessary to go into the subject-matter of those discussions. We believe, on the contrary, that we shall best consult the interests of our readers, as we believe also that we shall thus meet with their approval, if we confine ourselves almost with rigid closeness to the practical matters about which there is no dispute, and which, if many of them have not met with precise definitions in which all men are agreed, have at least—and this is for our reader much more to the point—received all the advantages of a long applied and carefully thought-out experience: an experience which, as we have already pointed out, has given us all the triumphs of modern mechanical work. And theories which have led to this may well, as we have already said, be accepted by the reader beginning his study of the principles of mechanics.

At the same time, as we cannot come to a right understanding of what the principles of dynamics or the laws of motion are, and of the points to which we have in preceding paragraphs more or less directly alluded, without going somewhat fully into this point of "force," we purpose doing so, but nevertheless, for the reasons above given, as briefly as may be.

Some Practical Considerations connected with the Definitions of the Term "Force."

The term is derived from the Latin word *fors*, which signifies "strength," and is defined in dictionary or general language to be "active-power" or energy or strength. A more precise definition is given by one scientific authority: "force is that which tends to cause or to destroy motion." But this applies more to the effect than to the cause, and gives no clue to the answer to the question What *is* this "something" which is called force, which causes or destroys motion? And it is here that the wide and singular diversity of opinion or conception, leading to as wide and singular opposition in definition, arises. Into the metaphysics of this discussion—for much of it appears to be this, or what is very generally if somewhat irreverently called "chopping of logic"—and for reasons already stated, we do not intend to enter. We frankly confess, however, that so far as the student is concerned, whose work is now, or is in the future, to be connected with mechanism, he had better defer his study of this discussion, and all its involved and intricate points, till he has reached an advanced point not merely in the study of what might be called the "received opinions" of men of science, about which there is little dispute, but in the actual practice of the workshop, about which there is less. And we conceive it to be quite a possible thing that, having reached this "further point" in his life of study and practice, he will feel, in fact, that so little is to be gained by going into the mazes of those discussions on what at the best are and must be conjectures chiefly, that he will, so far from doing this thoroughly, be quite content with merely glancing at what is advanced by the parties who have taken or may yet take part in it. And in support of the advice we here give, it may be stated that the discussion is so confusing in its general results, so conflicting and contradictory in its statements, sometimes so wild or far-fetched in its hypotheses or suppositions, that, to quote the words of one of our ablest practical authorities on mechanical practice —not less able as a scientist—"a humble student of mechanics anxious to learn what 'the men of light and leading' in his generation have to tell him about the ultimate principles of his science stands by perplexed, embarrassed perhaps, at least a little indignant." But should any one of our readers after all mix himself up with these all too metaphysical disquisitions, it is quite possible, nay, exceedingly probable that, whether he may feel indignant with some of those assuming to instruct him or not, he will be ultimately indignant with himself for giving so much time to so little purpose. It will be well, indeed, if he escape incurring a more serious loss by giving up the study altogether, not "indignant" merely, but fairly disgusted, with the utterly irreconcilable nature of many of the conjectures made and theories propounded. How this may probably be the case, and how serious are the points involved in the advice we have ventured to give to the youthful reader in this matter, may be gathered from a further quotation from the paper by the able authority last quoted, in which, referring to one of the theories of force, or to an attempted answer to the question What is it? he gives these pregnant words: "The manifold confusions, the almost inextricable jumble in which the ordinary terms and conceptions of mechanics are involved by the adhesion to this wrong definition of force." We believe, therefore, we are giving advice which involves points of the utmost practical importance to the actual career of the young mechanic, to defer at least his study of this discussion here referred to, and with the able authority last quoted to be content with that view or definition of force which controlled the great men of the science—Newton, Moseley, Whewell, Rankine—or on which, to use the words of our authority, "they and their compeers have reared the magnificent fabric which goes by the name of mechanical science." It will, therefore, answer all the purposes we have in view, if we give here those accepted definitions of the term "force."

The Definitions of the Term Force which are received by the Great Majority of Scientific Men and Practical Mechanicians and Engineers.

"Force," as defined by the great Newton, "is an action exercised on a body tending to change its state either of rest or of uniform motion in one direction." Moseley defines it thus: "Force is that which tends to cause or destroy motion, or which actually causes or destroys it." Whewell defines it thus: "Force is said to be whatever produces, destroys, or changes motion"; and last, but not least, Macqhorn Rankine, the most eminent, practical, and scientific of recently living mechanical authorities, defines "force" to be "an action between two bodies, either causing or tending to cause change in their relative rest or motion." We could here give other definitions of men who have held high positions as expositors of the ordinary terms and conceptions of mechanics, all of which, in common with those we have above quoted, define force as "that" which causes the change. They do not, it will be carefully noted, concern themselves in the slightest degree with considerations as to what that "that," the "something" to which the name of force is given, really is. They know, and it will be well if the youthful reader also is content to know, that it is the *manifestations*, so to say, of this "something" with which they are in practice alone concerned. The practical mechanic, no less than the man of science, knows that when there is work to do and he has a force to do it with, he need not concern himself with abstruse speculations as to *what* that force is. It is, as we have just stated, the "manifestations" of that "something" called "force" with which he has alone to do.

THE WORKMAN AS A TECHNICAL STUDENT.

HOW TO STUDY, AND WHAT TO STUDY.

CHAPTER III.

THE last paragraph of preceding chapter was devoted to the importance of thoroughness in the doing of any work, or in following up any art so called. And we there pointed out how the word art was itself directly derived from *ar*, to plough, and proposed to show how it was that art could be likened to ploughing. (The reader interested directly in this subject will find the details of the plough itself, and of the cultural work it does, fully explained by a writer who all his working life has had to do with rural work, in the series of chapters entitled "The Farmer as a Technical Workman"; while the mechanical details of this important implement, and also of other implements, will be found in the series of papers entitled "The Agricultural Implement Maker and Country Blacksmith.") Now, ploughing is of a twofold character: first the plough digs or "burrows" into the soil, running below the surface at a certain depth, separating both vertically and horizontally a slice of soil from the general bulk of what is called the earth or land. And after separating this slice and appropriating it, so to say, to itself as an object in which it is closely concerned, it lifts it up and turns it over so completely, that what was originally the buried or under becomes the exposed or upper surface. And when the plough has done this, its appointed and predetermined work, it leaves the slice of soil to be further and finally operated upon by the "after influences"—a work of cultivation in which, as the reader who is careful to know will find explained in the chapters above referred to, the atmospheric influences, as rain, sunlight, and air, play an important part.

Now let the reader here pause for a moment, to see what a flood of light this brief search above has thrown into the meaning of, or rather what is actually involved in, the term art—derived, as we see it is, from the Latin verb to plough. Thoroughness is the very element or the essential condition of its being. An art, therefore, is something thoroughly done, and all work is art. How full and searching is the flood of light, then, which this investigation throws on the method of doing work! The soil, possessed of its valuable qualities, and its capabilities of yielding a certain desired result, is first dug up, and next turned over, so that it is in the best position to receive the after influences, which give it the quality of completed work. And this turning over of the soil so essential to the work cannot possibly be done till the severing of the portion turned over from the general soil is so far as required to be thoroughly and completely done. And now, taking our definition of "technical" science or knowledge in education in connection with all this, the reader will perceive in what its work really consists.

Practical Lesson in connection with Technical Education deducible from the foregoing paragraphs.

To impart technical knowledge, then, we find that the material—that is, the mind, the capacity for, and capability to do work—must first be found, dug for, burrowed for; it must then be lifted up and turned over, so that all the influences calculated to complete the work shall have free scope to work upon the material so dug up. As the soil has under its maybe rough and barren-like surface, constituents which, once "brought to light," give it the power to convert the old and comparatively useless land, growing only weeds, into the new and useful land, yielding crops good for man and beast; so every man possesses some qualities capable of being made useful. And just as the turned-up-and-over soil is cultivated afterwards, and brought under certain ameliorating influences which make its constituents all the more valuable, so in like manner are the hidden qualities of a man brought up from their original obscurity into the light, and placed, or can be placed, under *those influences which cultivate them into higher productiveness*. So far as the technical education of a man is concerned, we shall see as we proceed *what* those influences are. But meanwhile we desire to draw the very special notice of the reader to the fact that *all* those influences must be brought to bear, otherwise their full effect or rather the completion of the desired end will not be obtained. Still, keeping to the derivation or linguistic root of the word art, and to the illustration of the rural work it involves, we would point out that it would be but of little practical avail if the slice of soil were merely dug up from the general land, turned over, and left there to take what chance there might be of atmospheric influences surrounding it, alone acting upon it. Those alone would not suffice to make it fitted to receive the seed and to mature that till the final produce was obtained. Other and after processes—harrowing, rolling, clod-crushing, manuring—would all have to follow; and after the seed was sown, and the plants came up, these would have to be cared for—that is cultivated, or hoed, weeded, cleared and freed from choking weeds; and all those processes carefully and patiently done, before the heaviest crops would be obtained. And over all and through all, to the very end, the atmospheric influences would exert their power to complete the work.

Various Matters influence the Successful Pursuit of Technical Knowledge—Mutual Relation between the Teacher and the Taught, or the Student.

Here we see that it is not merely the employment of one, but of all the influences, and those not only intelligently but continuously exerted, in which what is called "cultivation" consists. So in like manner is technical cultivation or education characterised, in which all the influences and means at command—mental, physical, and (last, not least), moral—are availed of. And we do not hesitate to say that it would have made much greater progress than it has, had this great truth been more widely recognised and acted upon than it has. And the work of education—that is, bringing all the influences to bear—necessarily makes this a feature of it, that it is a work in which the two are concerned, the teacher and the taught. The teacher will have but little success in imparting what he knows, if the pupil or student is careless as to the way in which he receives. Teaching or study, in the fullest and most practical sense of the term, is thus seen to be a dual operation—one of giving and imparting on the one side, one of receiving and taking on the other—and although this is so, it not seldom is so forgotten that we hear of cases where the teacher blames the student, and the student recriminates upon the teacher, although the great likelihood is that both are to blame. And in this regard the reader must not conclude that in using the word "teacher" we mean to confine it to its ordinary significance of a living individual; for, so far as the student is concerned, his books, and the great book of nature ever open to him, take the place often of the living teacher. And so far as the capabilities of the student himself are concerned to be taught, or his capacity to take in an "explanation" of an "art," he will find, as we proceed to inquire into the meaning of the term "education," that it is the drawing out of those capabilities and their development which really, and in the highest and most practical sense, constitutes it.

Position of the Student in relation to his Education.

At the same time it will be found as a general rule that the fault lies with the student. He must be a very poor teacher indeed who has not much more to impart than many—we may say the majority—of his pupils receive. For experience, we think, will show that teachers can point to but a very few with satisfaction as having turned out first-rate scholars; the rest, after the first excitement and direct influence of the teaching is passed, fall into the ordinary ranks, some of the members of which are so little distinguished by aught superior to the general status, that for all the practical purposes of technical education they may be said to have never been at school or class, never been students. This, therefore, implies that the student, if he passes from his class in this condition here stated, must have had some special cause or causes operating upon him, or have allowed causes proceeding from outwards, or must have been himself the creator, as it were, of causes, which have operated upon him; and through these—if not actually thwarting the efforts of the teacher, certainly not aiding him—has been brought about the untoward result which we have named above, and which so many teachers have reason to deplore. There must be something radically wrong in technical education which results in so many who have gone through its curriculum passing away into a condition which practically is equivalent to never having passed through it at all. Of all the crowds which pass through their classes, let teachers say if many become men of mark in their respective callings in virtue of that which they endeavoured to impart to them when under their teaching.

The Facts connected with Technical Education as a System. Necessity to look fairly at those in order to arrive at a Just Estimate of what has been and what has yet to be done in it.

It is good policy—nay, what is better, it is right—to look facts in the face, and to set ourselves resolutely to find out what reason there is for so little comparatively having been effected in the matter of technical education. It is not enough to say that the supply of the means to impart it has been quite inadequate to the real demand, and that we are only just beginning to face the necessities of this demand by establishing technical colleges and schools. Of these, the good they are so well calculated to do and of the good they are *not* capable of performing, we shall in proper place have somewhat to say; but the real question we have nationally to face is, What is the reason why so little practical result has come out of the means of *imparting technical education* which we have for a pretty long series of years possessed throughout the country, taking it as a whole? It has been of very recent times, and is in fact now, too much the fashion, in our anxiety to make the machinery of technical education, if not complete, at least much more extended than it is now, to argue as if nothing at all had been done in the matter. It is not so, and to say that it is so is to do great injustice to the teachers and their classes who have been working patiently for years, alas! with the little practical result we have above drawn attention to. And of this we may rest assured: that the mere establishment of technical schools and colleges will not alter this result very much, unless we ascertain what the causes have been which have brought it about, and if possible do away with them. We hope, in the course of such counsel as we shall do our best to impart, to show students how they should study and what to study, to be able to point to a few at least of the causes which have—as experience in the matter leads us to believe—operated hitherto, and are likely in the future yet to operate if not met and overcome, in bringing about this unfortunate result.

THE ORNAMENTAL WOOD WORKER AND DESIGNER,

In Carpentry and Joinery, chiefly for Exterior Work.

BEING ONE OF THE SUB-SECTIONS OF THE PAPER ON "FORM AND COLOUR IN INDUSTRIAL DECORATION."

CHAPTER III.

In the concluding paragraph of last chapter we stated generally that in timber structures could be as cheaply obtained of pleasing design as those which were unpleasing. This is true, at all events, of the plain or general outline of the structure. And as regards the point of details, at but a very little extra cost very beautiful effects may be obtained. And why people should grudge a little extra cost in making the outside of their dwelling-place a "thing of beauty," while they will go to even a lavish expenditure in filling the interior with objects of beauty—at least at much cost *aiming* at this—we confess that we fail to see. Let it be remembered that a structure perpetuates either beauty on the one hand or ugliness on the other, and that as a monument of the one or the other it is *constantly* staring us in the face, "in our going out and in our coming in." And if this one fact be borne in mind, it ought to influence us in making our permanent abode that which is pleasing to the eye and gratifying to the taste. Nor let it be forgotten—what is, however, but too frequently overlooked—that in this we owe a duty to our neighbours. It is all very well to say that each man has a right to do "that which is pleasing in his own eyes." But this right has its limits, and to a man of a well-constituted mind the truth is ever present that his public conduct—so to call it—shall be so guided and directed that he will not willingly "give cause of offence" to those he dwells amongst. And it shows a sad defect in the æsthetic estimation of the popular mind when numbers prefer an ugly to a beautiful thing; or, as we perhaps should put it as more correctly stated, that they are ignorant of what constitutes the difference between the positively ugly and the actually beautiful. Nor does it the less argue a sad defect in the *morale* of the popular mind when numbers claim as their privilege, and assert it in their work, that they have a right to erect structures which are painful perpetuations of all that is grotesque or hideously ugly.

Practical Value of the Foregoing Considerations in relation to Ornamental Construction or Decorative Design of All Kinds.—The Position of the Young Artist in reference to Design.

Such considerations are so far from being out of place here, that they have the closest possible bearing upon the present section of the subject named in the title to this series of papers. For it is not enough that we give, as we propose now to give, what may be called the alphabet of design in timber construction. This is necessary, but something more is required. For although a pupil may be taught to read—that is, have a knowledge of what may be called the mechanical part of the art, so that he can tell each letter, and pronounce or read any, however complicated, of their combinations—it rests with himself that he reads so that he understands. The teacher has, so to say, provided him with the bricks or stones by which he can erect a building, but it is the pupil who must put them together in proper fashion. So, although we give in succeeding pages what we have called the alphabet of design, the pupil must not suppose that a knowledge of its elements constitutes design proper. To exercise this, the pupil must think for himself, must cultivate a love for the beautiful, and to do this he must observe and closely study in various directions. What those are he will find detailed in the papers in this work given under the head of "The Ornamental Draughtsman." And we have also indicated in the foregoing remarks in this chapter some other points which should influence and guide him in his practice. The whole subject of art education is so wide, embraces so many points of special importance, that after all that may be said, complete as it may seem to be, something more, it is felt, remains to be given. The subject is one which, after receiving the elements, the pupil must in fact think out for himself. There is in this, as in all departments of knowledge, no "royal road" to its attainment. The way is often very rough, always more or less difficult to be trodden; and, like one who is ascending a mountain, the object seems about to be attained, when further advance only shows that it is farther off than ever. It is not given to every one to reach the mountain top, but it is given to every one that if he chooses he can at least have a desire to leave the valley, remembering that each step taken is a step which places him on a higher standpoint than he occupied before, from which he can command a wider prospect and breathe better and purer air.

Points connected with Artistic Design as Applicable to Constructive Work.—The Method of Treating the General Subject of our Papers.

We have this further by way of introductory remarks to notice: that the examples we give are to be taken more as suggestions for practice in design, than the actual details to be rigidly followed. This is the outcome, indeed, of what we have said as to what constitutes true design. As in "The Ornamental Draughtsman," and "The Technical Points connected with Form and Colour in Industrial Decoration," the authors of the papers under those heads have given the elements of the art, leaving the pupil to design his own combinations of them as applicable to any particular work he has in hand, so in the present series of papers we give the foundation—the pupil must on that rear the superstructure. The design, as such, must be his

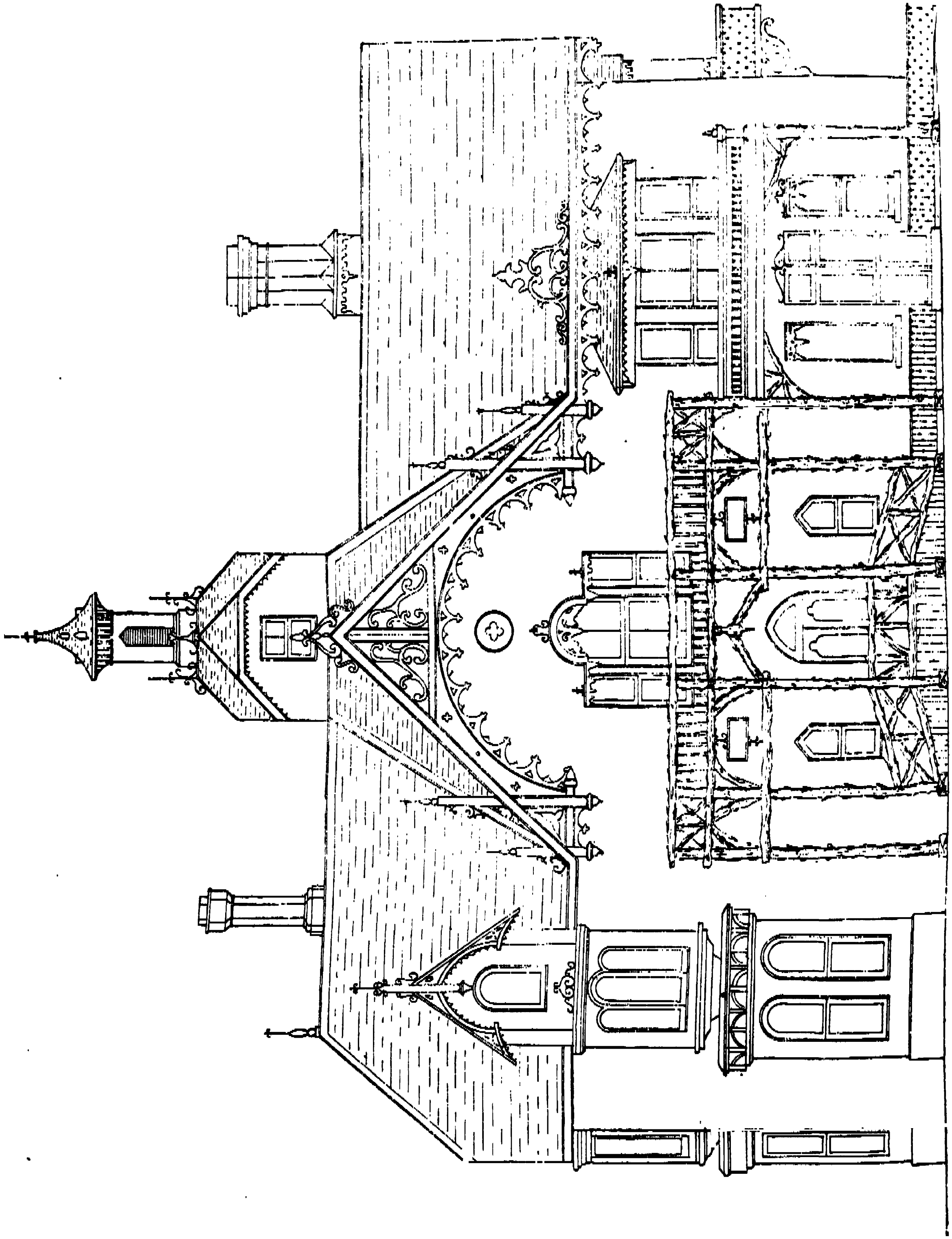


Fig. 1.

"very own." We are far from saying, however, that the examples we are about to give are to be taken for, or useful only as, suggestions of design in detail. We may very easily claim for them a higher utility than this. For being taken almost in every instance from examples of executed work abroad, either from sketches of our own taken on the spot, or obtained from the many and special sources of information open to us, they may with all safety be accepted as details which may be executed in our practice of construction. They must, of course, be used with judgment, if used at all in this way, and be taken so as to preserve a unity in the design as a whole, whatever be the leading characteristics of its details.

General Characteristics of the Ornamental Work of the Carpenter or Joiner.

Following out the subject opened up in the preceding paragraphs—namely, that of ornamental wood work—we proceed to the consideration of that department of it which deals with the details of the art. These details, of course, when put in position, or *in situ* (see "The Stone Mason" for the meaning of this term in construction, also "The Dictionary of Technical and Trade Terms"), make up in combination part of the structures the general design or form or outline of which will be in another place discussed. It does not follow that those details, more or less ornamented, are to form part of a building wholly constructed of timber. They may be used in conjunction with and be employed to give a graceful elegance to structures of the more durable materials of stone and brick. Some notion of the effect of this combination may be obtained by an inspection of the design- specially prepared by us for the purpose—given in fig. 1.

The General Form in which Timber is used for Ornamental External Wood Work.

So far as these details are concerned, the ornamentation used to give the æsthetic or artistic effect aimed at is obtained by two methods of treatment of the wood. This for details is for the most part used in the form of planks or deals (see "The Timber Dealer"). The one is employed in the body of the plank, the other along one or other of its edges. The ornament in the body or face of the plank or piece of deal appears in the form of perforation—that on the edge or outer line as what is best described by the popular term "scalloped." The work is thus simply effected by cutting, this being done in the small scale by hand, in the large by machinery. The latter work gives on the Continent rise to a special trade the members of which supply to builders and carpenters a wide variety of planks or deals cut according to different designs. The trade or art of the trade is in France known by the name of *Bois découpé*, or, as we should term it, "cut wood." The pleasing effect obtained by treating wood used in construction in this fashion may be illustrated in detail by fig. 3, and in combination in the design in fig. 4, and in figs. 6 and 3, Plate XXI.

Practical Examples.—Simple Elements or Details of Ornamental Wood Work.—Flat Surfaces.

Fig. 2 may be taken as illustrating the very plainest way in which it is possible to present a part of a structure, as for example at the horizontal lines of eaves boards, or the angular lines of a gable. Contrast this with the very next or most simple advance which can be taken in its ornamental treatment, and the pupil will admit that there would be something more pleasing to the eye if the bald plain edge of *a b*, fig. 2, were treated throughout by a repetition of the exceedingly simple ornament in fig. 3. Still more would this effect be obtained in the next advance, as the design shown in fig. 4, and still more so in fig. 11, Plate XXI. The *tout ensemble* of the edge of a board, plank or deal, treated with some pretension to artistic design, may be gathered from fig. 6, Plate XXI., which is in design of a very simple character. A more ornate example is given in fig. 4, Plate XXI.

Fig. 2.

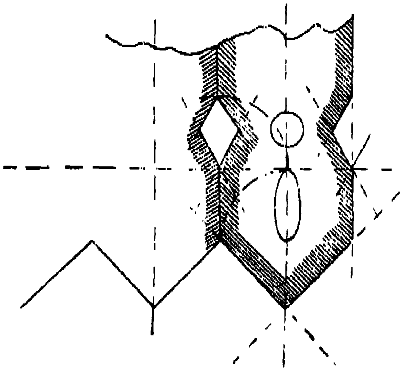


Fig. 3.

Continuation of Examples in Detail.

In this a further advance in the artistic treatment of the wood is observable; for we have the two features formerly alluded to—namely, the perforation in the body of the board, as at *a a*, with the treatment of the edge or outer line at *b b*. The effect of perforation in a higher ratio of advance is given in fig. 1, Plate XXI. And here will be noted how the extreme edge, as *a b* in fig. 2, given above, of a flat board may be treated, as at *a a* in fig. 2, Plate XXI. In place of cutting the edge up into scalloped parts, as in fig. 6, same Plate, the whole edge is treated throughout so as to form a pleasing curve from one end to the other.

THE IRON MAKER:

THE DETAILS OF HIS WORK AND THE PRINCIPLES OF ITS PROCESSES.

CHAPTER II.

We concluded the preceding chapter by stating that in their anxiety to give the greatest antiquity to the iron manufacture, some writers go back to the very earliest times from which to date it. But that those references are purely conjectural, and not based upon reasonable data, is pretty well proved by the closer investigations of more careful writers and authorities. Thus it seems pretty well established that, although in the earlier writings both of Scripture and pagan authorities, the word iron is often met with, it literally means bronze. This metal, a compound of copper and tin, beyond all doubt was largely used both in the fabrication of vessels for domestic purposes, for use in religious worship, and for the making of implements of war. And if one carefully traces the practical details, the making of iron, from the earliest times when we have records, however scanty, still of undoubted veracity to fall back upon, it will not be difficult to conclude that the ancients would have greater ease in the production of articles of copper, and of bronze as made from that metal, than in those of iron. How this is we shall see as we go further into the subject; but one point alone need be named here in proof of the conjecture—that the metal copper, in being reduced from the ore so called, was produced in such a form that it could be *cast* or run into *moulds*. Now, from the earliest recorded statements in connection with the history of iron, up to what may be called comparatively a very recent period, the manufacture of iron was confined wholly to the production of the material in that form now known as "malleable" or "wrought"; the production of "pig iron," to use the modern term, or that which would be cast or run into moulds, being a discovery made within times so very nearly approaching our own, that in view of the long ages of the world's history, it may well be stated to be at least comparatively quite a modern invention.

Now, the reader will see that the capability of so treating copper that it could be smelted, melted, or, to use the technical term, "reduced" into a fluid state, and in that condition run or poured into moulds, would give great facilities for the formation of a wide variety of forms, whatever the objects so moulded or cast were used for. And when we consider another peculiarity of the metal—its extreme ductility, by which it could be drawn out or hammered into various shapes—we see another reason why the making of articles of copper and of bronze would be carried out to a large extent by ancient artificers. Brass, a compound of the same metal and zinc, would probably be discovered at a later date, as the alloy is more difficult to make than that of copper and tin (bronze), from the tendency of the zinc to volatilize and pass off in the form of a metallic vapour. Another reason why it may fairly be supposed that the making of articles of iron followed at a later date than that of copper ones, is that the ores of iron practically are never met with in a state of purity, being almost always found associated in greater or less proportion with impurities which exercise a very deleterious effect on the quality of iron produced. We shall see as we proceed how largely this circumstance has affected and still affects the progress of the iron manufacture towards that economical and complete success at which iron makers are still at this day aiming; the existence of those impurities in the ore having, so to say, necessitated and brought into existence those very improvements in the manufacture which, both in their scientific and practical characteristics, constitute the most remarkable as it is the most gratifying feature of the iron trade, in its technical and industrial aspects.

Copper and the softer metals being generally found in a state of purity, or at least very little deteriorated by impurities affecting the easy reduction or the quality of the ultimate metal, for many reasons—one only, indeed, needed to be operative—man, therefore, in his earliest stages of civilisation, would use only those materials which could be most easily availed of, for his contrivances would be of the crudest, his appliances of the simplest character. Iron ores, therefore, it may be reasonably predicated, were amongst the last used of metallic substances.

The Early Workers in Iron.

As we have said, history is really silent as to the country in which iron ores were first used for the production of articles fitted for the use of man, either in his quieter sphere of domestic life or of trade or commerce, or of the fierce and ferocious wars and predatory excursions which at one period seemed to be the chief work of his existence. The earliest, certainly the most extensive and by far the most successful, searchers after and users of metal ores, were the Phœnicians. This seems to be admitted on all hands. And the probability is that they were the first to find and to hit upon a method of using the iron ores, in their extensive workings in metal. From a very early period they carried on an extensive trade with the ancient Britons in the purchase of tin procured from the mines of what is now known as Cornwall. Some authors state it as their belief that it is to the Phœnicians that the introduction of the manufacture of a workable metal from iron ores is due. And there is much to favour this view, as it is not easily credible that a people who trafficked and wrought so much in metal ores and their products had passed by as useless. ores which were met with in such abundance, and that so readily that in some instances they crop out actually to, and in many cases are but a very little way below, the earth's surface. The very abundance, moreover, in which the ores of iron are met with in localities which are now known as the iron or ironstone districts, would, it seems only natural to suppose, attract the attention all the more certainly of those who, like the Phœnicians, had a practical acquaintance with metals. For it is one of the distinguishing, and to us as a people singularly happy circumstances connected with the iron trade, that its ores—and they are of great variety of constitution—are met with in thick or deep veins, and extend over vast areas of land, so that every facility is afforded for working the mines with comparative ease and profit. They are unlike, in this respect, the rarer and more precious ores, which are found only in limited areas or districts and not only so, but in limited quantities; the veins, or lodes as they are called, being thin and frequently interrupted by the presence of foreign materials, which interruptions have got the ominous name of "faults" attached to them in trade or technical phrase. Another, and as the reader will not fail to consider, a singularly happy feature of the great districts of iron ore, is that they are generally associated with, in fact, in near contiguity to, the coal fields. The result of this, in its practical form, we shall presently see.

The Romans as Extensive Workers in Iron while in Possession of Great Britain.

Whether, as conjectured by some writers, or not, the Phœnicians had imparted to the ancient Britons the secret of the use to which the ores of iron could be put, or whether, as some others hold, the ancient Britons had possessed it long before, certain it is that throughout the period during which the Romans had possession of Great Britain the manufacture of iron was carried on to a large extent. One of their largest, if not the largest, iron works was situated at Bath, this beautiful city having been chosen from its antiquity not only for the iron ore deposits, but the large forests, from which a supply of timber for the making of charcoal could be obtained. The vast mounds of scoriæ which long formed a distinguishing feature of the landscape in this region attested the extent to which the Romans had carried on the manufacture of iron. But it was not only to their work that the origin of those mounds of iron-trade *débris* is to be traced; for it is the opinion of some writers that many of them were the result of the iron-making carried on by those tribes of Northmen from the northern seas of Europe, who long and sorely ravished this country subsequent to the departure of the Romans from it. This view is sustained by the local name long given to those heaps of scoriæ in some districts—namely, "the Danes' cinders." Long an encumbrance to the land surface, if not an eyesore to the lover of nature, it remained for generations succeeding to the land centuries after to utilise much of the scoriæ of which they were composed, by employing them in the blast furnaces which were erected in the districts. How and why, we shall in due place describe.

Chief Locality of the Ancient Iron-making in Great Britain.

When we take up the detailed description of the three great classes of manufactured products from iron ores, we shall explain the ancient method of making iron—in which, as may be gathered from what we have just stated, charcoal was used as the reducing or smelting fuel. For a long time the dense and extensive woods with which large districts of England, chiefly to the south and south-west of London, were covered, yielded an ample supply of the wood required for the making of the charcoal. These woods gradually disappeared; and in order to save a remnant of them for other and natural purposes, it was made penal to cut the trees down for any purpose. This, with the positive lack of timber, almost virtually extinguished the manufacture of iron in Great Britain, and it was almost wholly carried on by Continental peoples, as those of Sweden and Russia, who yet possessed boundless forests of timber. Sweden, possessed of the finest timber, as also of the most valuable iron ores, rose into a distinguished position as an iron-producing country, which it has sustained, as we shall see, up till the present day. The general reader may perhaps here express surprise that any difficulty arising from a scarcity of wood could not have been got over by simply using the common coal of the country. But what has to be said in connection with this point opens up one of the most curious, as it certainly is one of the most suggestive, chapters in the history of the iron trade of Great Britain.

The Old Method of Making Iron with Wood as a Fuel—Suggestive Points connected with this in Relation to the Modern System.

We stated at the end of last paragraph that the difficulty to obtain supplies of charcoal in this country had brought the manufacture of iron to such a point that its production had almost ceased: so scarce had it become that in the reign of Edward the Third all exportation of it was prohibited under severe penalties. Practically, for long we were dependent upon the densely wooded countries of northern Europe, who, not only thus fortunate in the possession of an unlimited source of charcoal supply, were equally so in that of mines of the finest iron ores. The iron made in those early days of European civilisation, when the arts and sciences were only just beginning to show some symptoms of vitality, was of the kind or class we now know as malleable, or more generally wrought iron.

THE JOINER.

The General Principles and the Details of his Work.

CHAPTER IV.

Vertical Joint with Mortise and Tenon.

In the last form of joint illustrated the groove *e* is cut to a certain depth only, and across the full breadth of the piece *a a*; the width of the piece *b b* being supposed to be equal to this breadth; but in the joint in fig. 31 the width of the horizontal piece, as *d′ d′*, is greater than the thickness of the piece *b b*, which is to be jointed vertically to it, and which is to occupy the centre of the width *d′ d′*. The joint is effected by mortise *c′* and tenon *b* cut in the end of *a*. The mortise *b′* and *c′* is cut through the full thickness of piece *d′ d′*, so that the end of *b* may be wedged up from lower side of piece *d′ d′*. The tenon *b* is not of the full width of *a*, but is cut so as to give a shoulder at both sides of the tenon *b*, as shown.

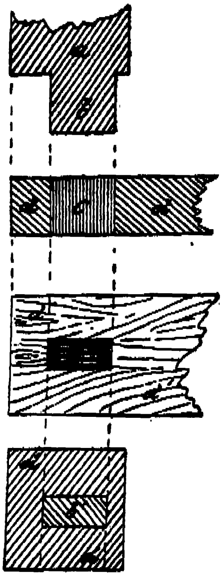


Fig. 31.

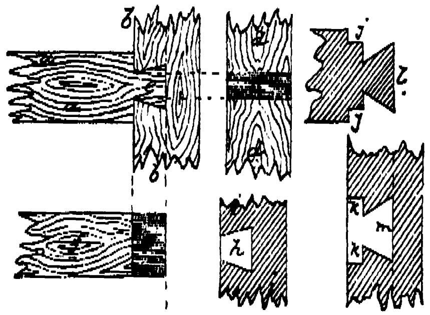


Fig. 32.

Joints for joining Horizontal with Vertical Pieces.

Fig. 32 shows a method for joining a horizontal piece *a* to a vertical piece *b*, both of which are of the same thickness, by a dovetail tenon shown in side elevation at *g*, and a corresponding mortise *h*. This is cut the full width across the face of vertical piece *d d*, as shown at *e*. In place of making the tenon as at *h*, in *i i*, it may be cut with shoulders, as at *j j*, on each side of the tenon *l*, corresponding undulations or hollow parts being cut out as at *k k*, *m*. Pieces at right angles to each other, as in preceding figure, are met with in framework very frequently, the pieces being generally of the same thickness, and often, though not always, of the same breadth. Thus, in fig. 31, *a′* and *b′* are parts of pieces joining as at the corner of a framing. In cheap work, the joint may be made on the "half-lap" principle, illustrated in fig. 12 (*ante*); a part equal to the breadth of the piece in length being cut out at the end of each, as shown by the dotted line on piece *a a*, fig. 33; the thickness of the piece cut out of each end being, of course, equal to half the thickness of the piece; and as the thickness of the two pieces is the same, the result is that when the two pieces are put together the surfaces will be flush on both faces. The two pieces will have to be secured together by nails or otherwise. But in a higher class of work the "tenon and mortise joint," as in fig. 26, may be used, as shown in fig. 33, in which *a′ a′*, to the right at top of diagram, shows the edge view or thickness of piece *a a*, having an open mortise *b′* cut in the centre of its width and at the extreme end, the depth of which is equal to the breadth of piece *b b*; this is shown at *e e* with the tenon *d* cut at the extremity, which is driven into mortise *b′* in *a′ a′*, end view *d e e* being at *c* in *a′ a′*. Or a double mortise and tenon joint may be used, the double tenon being as at *f* and *g* in end view, and *h h* in face view *i i*. For the joint thus made will be secure against any pressure acting in the direction of the vertical arrow 2, or horizontal one as shown in upper figure to the left; but pressures acting in directions opposite to those directions will tend to draw out the tenon from the mortise laterally or force it up vertically. To keep the whole in place,

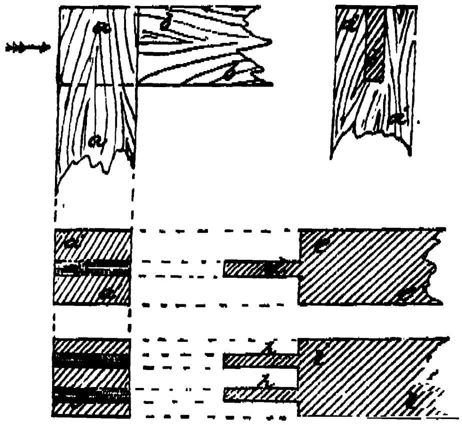


Fig. 33.

a wooden pin may be used, inserted into a circular hole cut through the piece *a a* and the tenon *d*. In fig. 33 A we give another form of this class of joint, in which the horizontal piece *b* is secured to the vertical piece *a* by the grooved and tongued part at *c*

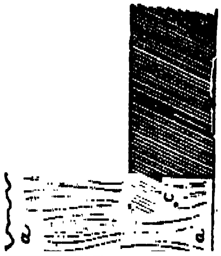


Fig. 33A.

A Modification of "Dovetail" Joining, as at the Corners of Two Pieces meeting at Right Angles.

In fig. 34 another form of joining pieces, as at the corner of a frame, is a modification of the principle of dovetailing, in which the mortise and tenon, in place of being plain surfaced, as in the last figure, are dovetailed. The mortise cut in the piece *a a* is cut across the end, and is open to this, as shown in end view at *d e f g* in *h h*; the depth being equal to the breadth of piece *b*. The end of piece *b* is cut out with a tenon as at *i* and *j*, and when the two pieces are placed together by inserting the tenon *i* in the mortise *d e f g*, on looking at the edge view at *a'*, of piece *a* in the direction of the arrow 1 to the left of the upper figure; the end of tenon *i* is seen at *b'* in cross hatching. Looked at in the direction of arrow 3, the whole presents the appearance as at *h' h'*, *i'* and *j*, those being the same parts as those correspondingly lettered without the accent. Pressures tending to separate the pieces are prevented by the form of the joint here employed, excepting in the direction of the arrow 2; and to meet this pressure or separating strain, a pin as at *c*, or in edge view at *i*, is passed through the two pieces from side to side, and finished off flush with both surfaces, not allowed to project, as shown in the diagram at *i*. When the dovetail principle of joint is applied to work, as in small boxes, or in a very complete way in larger work, the double dovetail is employed, as illustrated in fig. 35. In this form of joint it will be perceived that strains tending to separate the two parts *a* and *b* are met in both directions by the angular form being given on both sides.

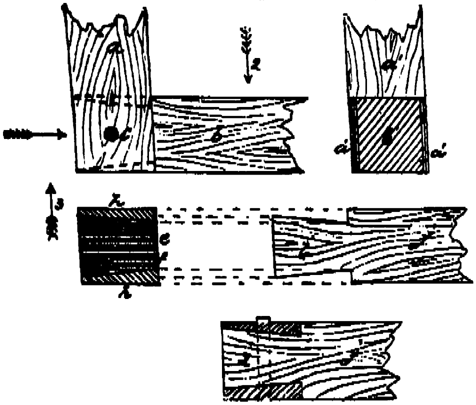


Fig. 34.

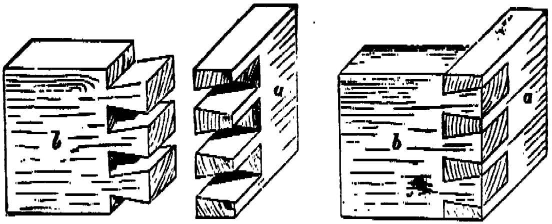


Fig 35.

The "Mitre" Joint.

Pieces as in framework are joined at right angles by what is called the "mitre" joint. In the illustrations already given, the end of each piece is cut off at right angles to the length. But in the "mitre" joint each end is cut off at an angle of 45° to the length, as in *d d'* of the piece *a' a'*, or *b' b'*, fig. 36. When pieces thus cut are joined face to face, as *c' d'* of *a' a'* to *c' d'* of *b' b'*, they are exactly at right angles to each other, or square, as at *a a* to *b b*, and the joint *c d* is termed a "mitre" joint. A side view of piece *b' b'* is at *e e*. The pieces when placed in position must be glued or otherwise secured. A mitre joint sometimes used is illustrated in fig. 37, in which a shoulder, as at *c*, is cut in the piece *a b*, giving the end of the form as at *a' c' d'*.

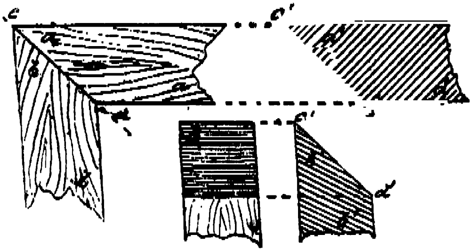


Fig. 36.

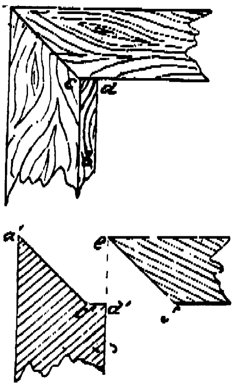


Fig. 37.

THE MACHINE MAKER OR GENERAL MACHINIST.

SPECIAL EXAMPLES OF HIS WORK—ITS LEADING TECHNICAL PRINCIPLES AND DETAILS.

CHAPTER IV.

Early Stages of the Science or Theory of Mechanics or of Machine Making.

In considering the circumstances of the early stages of the history of mechanism, as glanced at in the concluding sentences of the preceding chapter, it will be seen that in truth the science of mechanics has passed through the same stage which nearly every science has gone through—namely, that to which we may give the appellation of the infant or child-mind era. In this it is only the marvellous which excites attention; and one has but to glance over the early treatises known generally as scientific, to have abundant proof of this. The more clearly, indeed, the writer saw the value of the power, the more he seemed to revel in the extraordinary developments which could be given to it, and at the marvels of the work which it was destined to do for humanity. But the very characteristics of this child-like stage precluded, as of apparent necessity, all consideration of the real conditions of humanity; and its work was done, and only could be done, when the manly stage was reached, of which the feature is that work is to be done in the arena of daily life. A man of science, of the times we write of, thus saw as a child, thought and wrote as a child, nor could he easily put away childish things. Nor should it be forgotten, in connection with the science of mechanism, that what brought scientific men face to face with the necessities of mechanical work, was what the purely working machinist, so long despised by the pure scientist, had actually *done* in applying it to the necessities of daily life.

The Early Work of the Practical Machinist—Technical Lessons to be Derived from it.

While the theorist was plodding on from day to day, inditing his long and "dry-as-dust" prelections, describing machines as impossible in their working arrangements as illustrated, as they promised to do impossible things of marvellous little use to humanity —if they had been possible—the machinist was laboriously working out mechanical combinations and appliances which enabled the varied and ever-varying necessities of man to be provided for. His contrivances, slowly and all too painfully elaborated, helped to raise the coal and the iron ores from the mine, which without their aid had been inaccessible, and which many a writer who could in no way foresee what the machinist was capable of doing, deplored in dolorous language as certain to be inaccessible, and that but too soon for the welfare of mankind. Machinists slowly elaborated the contrivances by which vast tracts of land were freed from water and rendered useful in the production of food, without which they would have remained not merely useless in this regard, but wide sources of miasma—potent causes of disease. And in a lesser way, but still vastly useful, it was the machinist who devised and constructed the implements by which these lands, created, so to say, by him —for without his machines they could not have had existence—were cultivated. And as our population increased, and with its increase the demand for its clothing, it was our machinists who devised and constructed those machines which were substitutes for the manual labour by which for a long time clothing fabrics were alone made, and without which mechanical substitutions the ever-growing demand for materials could not possibly have been supplied. And so throughout the wide range of work required by man,—a range ever widening, not merely in consequence of his ever-increasing demands, but, curiously enough, by the very demands which one class of machinery makes for another. A most suggestive circumstance this latter, and of which the present work will abound in examples.

Difficulties with which the Early Machinists had to Contend in Making and in Improving Machines.

And all this work of the practical machine maker was done, let the technical reader ever bear in mind, in face of material difficulties of which the machinist of the present day, looking merely at the circumstances of daily work by which he is surrounded, can have no conception. He might devise a machine, with all the "cunning" (kenning or knowing) "of the true inventor," admirably designed to perform its work; he could arrange its combinations, and sketch out the several parts of which they consisted. But those parts were to be formed out of the rough materials at his command—the wood or the iron; and they could not be formed without the aid of mechanical contrivances, so that before a machine could be made to do its work well and economically, machines or mechanical appliances had to be found by which it itself could be formed. So that the "machines which make machines," or help to make them—the tools which formed tools, or assisted in forming them—had all to be discovered, made, and applied by the machinist before he could construct the machine he had to devise. The considerations which this fact brings up to the thoughtful mind are suggestive in the highest degree, and tend to place the labours of past generations of machinists on a much higher platform than many are disposed even now to concede to them, and to award to them a higher meed of praise for so successfully encountering and providing for the difficulties under which they did their daily work. In looking back, indeed, upon the times gone by—not so remote but what machinists now living, not yet deemed as the aged and retired, touched, so to say, their outer edge, and came in contact with the work done by our early engineers—it is in truth difficult to comprehend how it was that they did overcome the practical difficulties with which they were surrounded. Like brave men as they were—of that Anglo-Saxon blood which knows not how to be defeated—they knew they had a work to *do*, and they set themselves with a stout heart to do it as best they could. And but little record they left in the way of moanings over the difficulties they had to deal with—which matters little to us; and as limited their "notes" of how they overcame them—which to us of the present day matters a great deal. For such a record would have been simply invaluable, as it would have carried with it a vast amount of practical facts of the greatest service to us, not merely as giving us lessons how to do mechanical work, but grave warning as to how not to do it,—examples for avoidance, as we have already hinted at, forming almost as essential a part in the training of men as those for adoption in practice.

The Ability to Design or Invent greater than the Facilities offered to him who had to Construct, a Feature of the Early Times of the Machinist. - The Difficulties of the Celebrated James Watt, the Inventor of the Steam Engine, in the Construction of his Engines.

In the preceding paragraph we remarked that the difficulties which our early machinists met with in realising the machine designs formed not the least part of those they had to encounter in applying mechanism to the work of everyday life. It would perhaps be more correct if we said that their difficulties in the way of making or constructing a machine were much greater than those in the way of designing it. In point of fact, ability to design far outran the facilities to construct. And in a sense it is painful to think in how far and by what so much mechanical progress was hindered—being put back in some instances, or rather put forward, by many years, from pure lack of the facilities to construct.

We have before us a paper read recently at a meeting of the Institution of Mechanical Engineers by Mr. E. A. Cowper, one of our ablest engineers, on "The Inventions of James Watt, and his Models preserved at Handsworth* and South Kensington." In this paper Mr. Cowper gives the following:—"It is worthy of note that in a letter to a friend he (Watt) said that he thought he had got his cylinder bored so perfectly that you could not get a half-crown between the piston and the cylinder anywhere. Now, we must not be altogether surprised at this remark when we consider with what material he was in the habit of making his models. He used tin cylinders and soldered joints in many cases; and in one letter he says 'the cylinder was not very true, as it had not been bored but was hammered'; and in another letter he says that he shall in future make his cylinders of copper, as though that was a great improvement upon the material he had been using. He speaks of his 'White Iron Man,' who was so useful, being dead—meaning his 'Tin Man'; *but it does seem sad* that a block-tin cylinder that he used, eighteen inches in diameter and a quarter of an inch thick, should be three-quarters of an inch out of truth; and he speaks of trying to improve it by hammering it with a mallet on the outside on a piece of wood fitted to the inside. It is curious to think of an optician and mathematician spending time over such imperfect work. His partner, Boulton, one day writes to Watt, who was away, that he had put in hand a block or boring head to bore a 'cast-iron' cylinder, then in hand, probably one of 7½ inches in diameter."

The Difficulties with which Watt and all the Early Machinists had to Contend full of Suggestive Lessons to the Technical Student.

If the young technical reader will think over this extract, he will find it most suggestive to him of what were the difficulties with which the early machinists had to contend, not in the matter of design—although everything had to be done in this *de novo*, from the circumstances in which they were placed demanding work of an entirely novel description—but in the matter of construction. And we may repeat that it would be difficult to overestimate the value of the lessons which could have been learned from a record of what our early machinists had to do in overcoming the difficulties of construction. Unfortunately, such a record does not exist in anything like a complete condition: so far from complete that we have but an entry here and there, and even then with details of the briefest and most fragmentary kind. Even in the case of Watt, the father of modern power-machinery, we have details so few and far between that it is only by reading between the lines, as it were, of such scanty records as are left us, that we can guess at the difficulties he had to encounter to give to his marvellous inventions a working value. But although guess-work be all, or nearly all, that we have to fall back upon, we have enough to guide us to some accurate conception of what our predecessors in the mechanical world had to do, the difficulties they had to contend with.

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* Heathfield Hall, Handsworth, near Birmingham, the residence of Watt—now occupied by Mr. George Tangye, the member of a well-known firm of mechanical engineers at Soho, near that town, and who takes a pride in retaining the room occupied by Watt as a study and workshop in the original state, and with its contents as left by the great inventor. As many of the models, etc., have been going to decay, Mr. Tangye, with considerable care, has had photographs taken of them—a process of recording which has proved in some cases no easy matter to carry out.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

55. The Condition of Pulley Surfaces.

IN notes in preceding parts of the Journal we gave a variety of information on certain points, as those bearing upon the strains to which belts or straps are subjected when being passed round pulleys in the best position in which the belt could be placed so that their strength to resist those strains would be best given out—that strength being different on the two sides or surfaces of the leather. We have shown that the grain side of the belt is, or should always be, put to the pulley, as it is the denser, more compact, and smoother of the two sides of the leather. We have also drawn attention to the form or section of the rim, or part of the pulley gripped by the belt, and how that affects its actual working; and we stated the reason why this was necessary to be given to it. In that note we stated the way in which the motion of the belt was due to the adhesion between its surface and that of the pulley. We have said that those who have a practical acquaintance with belt gearing know but too well all the annoying losses of time and temper arising from the "slipping of the belt," or rather, to put it more correctly, the slipping round of the pulley failing to catch or grip the belt. The surface of pulleys, that is of the rim or loop, is, in order to bring it to the right form and exact diameter, finished or turned in the lathe till a uniform and a smooth surface is obtained. This is just so much in favour of the slipping of the belt; and to prevent this a number of methods have been introduced into practice. Before proceeding to describe them, it will be useful to glance at some of the points involved in the slipping itself. Some machinists think little of this slipping, and by employing the most commonly adopted means of preventing it when it interferes with the steady working of their machines, think they have done all that is necessary or which can be done. But there is more involved in the point than this. For while an actual loss of power is created by the slipping *per se*, the means used to prevent it may and often do bring into existence other evils which not seldom eventually entail considerable loss. The slipping of the belt in too many cases is but too apparent, being so decided that to keep the machinery in motion—a stoppage being inconvenient and likely to cause loss or damage—expedients are compelled to be resorted to which do often considerable mischief. But slipping in many cases is not so obvious—indeed, it is sometimes somewhat difficult to ascertain that it exists—and yet it may be existing, and if so a certain, often a great, loss of power will be the result. This difficulty in observing or making clear the slipping is just all the greater the more accurately the tension of the belt and the arrangement of the set of pulleys is secured. Still if the space passed through by the pulley surfaces during a given time be carefully reckoned, and also that passed through by the belt, it will very likely be found that the speed of the belt on the number of feet it has passed through is less than that of the pulleys. We are here supposing the case of two pulleys of equal diameter. But in other cases there may be this difference between the speeds: that of the belt being less than the speed due to it under the arrangement; and whenever this difference of speed exists it is decisive of the fact that the power which it is the purpose of the belt and pulley arrangement to transmit through the agency of the belt is in excess of the friction or "grip" of the belt upon the iron surface of the pulley—or what is the same thing, although conversely perhaps more clearly stated, the grip of the pulley being less than that required to transmit the power, so much of that power is necessarily not used, and of course this is equivalent to a loss. It is requisite here, as in all cases of trial or experiment, to take into consideration their conditions. For if the speed be great the difficulty in regard to the grip is less than when the speed is slow; and on the other hand, if the pulleys' rims are large in diameter, the conditions are all the more favourable to the running without loss of power, if for no other reason than that the belt surface in contact with that of the pulley is increased, which of course increases its "grip." In the case of small pulleys the surface of the belt in contact with the pulley gives small grip or hold, slipping or sliding of the pulley within the belt without dragging it round being therefore much more likely to take place, and this the greater the power to be transmitted. Even a small difference between the velocity of the "driver" and that of the "driven" pulley, when both are of equal diameter, amounts to a considerable percentage of loss of power. In some cases experiments have proved the loss to be as much as one-fifth of the motive power desired to be transmitted. We have said that several devices have been and are tried to overcome this source of loss through belts slipping. And the reader who is new to the subject should note that by slipping of the belt is not meant here the slipping off of the belt altogether *away from* the pulley. This we have seen in a preceding "note" is provided for by making the periphery of the pulley with a rise or swell in the centre. But the slipping—so called—of the belt here being considered is more correctly designated the revolving of the pulley within the belt, so that it does not take a "grip" of it, or, which is the same thing practically, does not allow the belt to grip it—although there is a difference between the two conditions of a "driver" and a driven pulley in this respect, it being the "driver" pulley which grips the belt and drags it round with it, while it is the belt, thus moved or dragged, which grips the "driven" pulley, causing *it* to revolve. Now, when the pulley revolves for any part of its periphery without gripping—or, so to say, seizing hold of the belt and dragging it round with it, the belt is said to "slip," although, as we now see, it is the pulley which slips past the belt without dragging it. A very common device is to pound resin into a powder more or less fine, and strew a little on the inner surface of the lower side of the belt. This carries it along till it passes between its surface and that of the pulley. The young reader will perceive how this tends to increase the adhesion between the pulley surface and the belt, and enables the necessary "grip" to be obtained. But this method is only a palliation, and so far from being a cure of the evil, it lasts but for a comparatively short time efficient. The resin is so absorbed by the leather, and is so acted upon by the running of the pulleys, that the inner surface of the belt gets so smooth that the slip is worse than before. And if the palliative is frequently applied, the resin gathers on the surface of the pulley, so that lumps here and there are formed on it, to such an extent sometimes that we have seen a pulley surface so dotted all over with little lumps or hills of concreted resin that the diameter of the pulley was considerably altered, being made, so to say, larger. In place of resin, pitch is sometimes used; but this is worse—certainly a much more uncleanly remedy than the resin. Of such adhesive compounds the best we have heard of is printer's ink; this is said to be thoroughly efficient, although we have never tried it. Another great disadvantage of the method of increasing the "grip" of belts by the use of resin or pitch is that being absorbed by the leather, it seems to have the effect of destroying its integrity, causing the belts to get brittle and liable to quick deterioration. We should be inclined to think that the printer's ink, above named, would not have this effect upon the leather, but rather, if anything, in the direction of improving it. Failing these palliatives, or expedients, efficient only for a time, the method of preventing slips by altering the character of the pulley surface has been introduced, and with varying success, according to the substance used as a substitute for the ordinary iron periphery of the pulley. Of these substances wood is one; and we can easily conceive how this material was thought of as a covering for pulley surfaces: it is light, clean cutting, and easily adapted to broad surfaces, and can have its surface roughened. But ready as it is for adaptation, and much as it has been used, it has the great defect of becoming very smooth under the repeated and continued motion of the belt over its surface—so smooth that it becomes glazed and polished, and presents, though in a different way, the same defect which causes and aids slipping of the belt on the smooth and ultimately polished surface of an iron hoop or rim. And to obviate this, recourse is had to roughing up the wood surface by going against the grain of the wood. But though this is effective, it is only so for a time, and it possesses this great defect—that in time, the roughing process being again and again repeated, the diameter of the pulley becomes less and less. And although this does not much matter in gearing where the speed of the driven pulley and the "driver" is not required to be maintained in very precise and exact relation, or the transmission of the power precisely regulated, still in cases where these are required to be kept up and maintained in definite proportions, it is obvious that the use of wood for forming the surfaces of pulleys must be very limited; and this limitation is still further increased by the fact that it can only be employed in the case of large pulleys; the difficulty of fixing it to small ones being practically so great that they are quite excluded from consideration.

In presence of the difficulties of employing the methods now named it is satisfactory to know that a material much more easily adapted to pulley surfaces than wood is obtained in leather. The grip, or the coefficient of friction of leather upon leather is much greater and higher than that of leather upon iron, in the proportion of 1¼ to ¼, or 1·25 to 0·25—which gives five times the grip when leather running upon leather is used as compared with that, as in ordinary cases, where the leather (belt) runs upon iron. The leather, moreover, being so lithe, is obviously capable of being bent round and easily applied to the face of the pulley as no building-up or piecing is required—for many pulleys one length, giving one joint, being applicable. The application of the leather length is very simple, the glue used to attach it to the surface of the iron being easily prepared, it being of the same kind so largely employed in cotton factories for covering the rollers of spinning machines. The surface of the leather on its pulley side may be kept rough, which also greatly increases the grip, by simply using any salt solution, or a solution of alum. Another great advantage of this leather-covered pulley system is that the deterioration of the leather itself is not caused by it, which is the case in long running of a belt running on iron pulley surfaces. In process of time small particles of iron are rubbed off by the belt, and these get worked gradually into its interior; and the iron, with the tannic acid and fatty or greasy acids present in the belt, set up chemical action, which has a powerful deteriorating action upon it. Still further, an advantage obtained by the use of leather covering to the pulley is this, —that the grip being greater than in the ordinary surface, the belts can be run much slacker than when the ordinary method is employed. This of itself is a very great saving of the belt, as the tight working so often required is not necessary, and the lower the degree of tension placed upon the fibres of the leather the longer will the belt last. We could cite several instances where by the adoption of the leather-covered pulleys much more regular running of machinery has been obtained, and by consequence a higher quality in the work done. It is not always easy to estimate the precise gain obtained, or the working value of an improved method of working; but a large number of experiments would seem to put that of leather-covered pulleys compared with ordinary surface pulleys at 33 per cent. We have by no means exhausted all the points connected with the subject of the pulley in belt gearing, so that we shall return to it in a future note.

56. "Harmony in Colour."

An enthusiastic musician was once descanting on the "beauty of discords," a phrase which to the listener, who made no pretensions to a knowledge of the intricacies of musical science, seemed to be but a contradiction in terms, somewhat equivalent in truthfulness to what we might call the harmony of inharmonious sounds. Be this as it may, it may be safely remarked that there is no such thing in the colouring of Nature as discords. No matter what may be the variety of colours she displays, no matter how striking, and even, as in many cases—especially in tropical countries, as for example in the forests of South America—startling the contrasts she offers for our inspection, she never offends; in everything there is that exquisite balance to which we can give no more expressive name than that of harmony. And of how much in the way of variety of colours, of tone and tint, Nature throws abroad with lavish and loving hand, even in such a limited surface as a moderate-sized, weather-beaten, moss-stained, lichen-lined rock, or a patch of seaweed, or, for the matter of that, in a yard or two of a much-despised hedgerow bottom in country lane or field, it is given, and only, to observant lovers of nature to know. The failure to hit upon a like harmony of colour in ornamental decorative work is the cause of so many "designs," which may be otherwise good in conception as to form, and even arrangement of parts, turning out, not merely negatively bad, but positively painful. To the educated eye which can explain the reason why of such failures, they are highly offensive, and even to those who are not trained in this direction, while they cannot explain how it is, they are nevertheless fully alive to the unpleasant effect produced by their inspection of such defective work. What may be called the theory of colour in its technical or educational sense the reader will find explained and illustrated by coloured examples, which can alone convey what is meant, in the paper in the text under the title of "Form and Colour as applied to Industrial Decoration." Meanwhile, the object of the present note will be served if we give here a few "contrasts in colour," as formulated by an authority on this department of industrial art design, which will give that harmonious arrangement which, as he well observes, is to the eye like a "sweet chord of music to the sense":—(1) Black and warm green; (2) black and warm brown; (3) blue (deep) and golden brown; (4) blue (deep) and pink; (5) blue (deep) and maroon; (6) blue (bright) and chocolate; (7) green (warm) and maroon; (8) green (pea) and chocolate; (9) green (pale) and violet; (10) red (deep) and grey; (11) buff and claret; (12) rose (light(and violet. (See notes and illustrations on what are called the "complementary colours" in the paper in the text last referred to.)

57. The Preservation of Iron Surfaces.

The great readiness with which the surface of iron becomes coated with "rust," and the strength and beauty of iron structures diminished, renders it a matter well worthy of thorough investigation to devise some plan of making iron proof against oxygenation. The most usual method adopted is to cover the entire surface of the metal with some such paint as red lead, so as to exclude entirely the atmosphere and water with their oxidising action. The great objection to this expedient is that the paint itself, whatever it may be, is not lasting; sooner or later it is acted upon by air and moisture, and comes off. The result is that the paint has to be renewed periodically, and this means trouble and expense. Another method for protecting iron from the action of air and water is to coat it with some other metal of a less oxidisable nature than iron: zinc and tin are the metals usually employed; the latter forms "galvanised iron," and the former "tin plate." Although this plan is in many respects preferable to that of paint, the great defect about it is that neither zinc nor tin are very durable metals; besides, they cannot be used very extensively, and when galvanised plate iron requires to be cut—*i.e.*, *after* being galvanised—the edges present the unprotected metal. The Barff (better known now as the Bower-Barff) process of treating iron to render it rustless is free from each of these objections, and is now extensively employed. In a future "note" we shall treat this important subject at some length.

58. Steel Making by the Basic Open-Hearth Process.

Those of our readers interested in steel manufacture will be aware of the difficulty of obtaining soft or mild steel of great purity by the ordinary Bessemer or "acid" process, or by the Siemens or Siemens-Martin process; especially is this true in the case of using certain pig irons containing much phosphorus. The reader interested in the subject, but not acquainted with the principles upon which these processes are carried out—and the "basic" process of Messrs. Thomas and Gilchrist, which promises greatly to alter, as is the opinion of some to revolutionise, certain departments of the iron and steel trade—will find full information respecting them in the papers in the text entitled respectively the "Iron" and the "Steel" Maker. The following process has recently been tried by the Farnley Iron Company, near Leeds, and with satisfactory results. The furnace was prepared for the process in the following manner. The lime basin of the furnace was first laid with good magnesia bricks, carefully made for the purpose from magnesite, containing 98 per cent. of magnesium carbonate. Above these were built a layer of bauxite bricks, specially made from bauxite containing 15 per cent. silica, 82 per cent. alumina, 1 per cent. lime, and 2 per cent. ferric oxide. On the top of the bauxite bricks were laid the silica bricks. The furnace was provided with an arrangement whereby the slag, frequently containing a portion of the phosphorus contained in the charge, formed during the early stages of the process, could be readily removed. When the furnace was ready for the charge a quantity of well burnt lime, equal to about one-twentieth to one-tenth part of the weight of the pig iron, was laid on the bottom of the furnace. The pig iron was then added, and iron or steel scraps charged on the top of the pig. After some four hours' combustion the slag was tapped off; in six hours the entire charge had melted, and more slag was taken off. When the mass was at this stage of the process too fluid, some lime was added; and an addition of ore was made when the quantity of scrap iron or steel in the charge was small. The fluid being now sampled and found satisfactory, the slag was removed and about 5 per cent. of hæmatite pig added, which had, as soon as melted, the effect of causing the metal in the bath to boil for about fifteen minutes. This ebullition thoroughly agitated the fluid, and a further elimination of phosphorus took place. When half an hour had elapsed a further quantity of slag was removed —in fact, all the slag now collected was taken out, except as much as served to cover the top and protect the molten metal from chilling when ladling into the casting moulds. The furnace being emptied of its contents, the small quantity of slag which reached the bottom was removed, and the bottom repaired with magnesia-lime. The soft steel obtained in the Farnley Iron Company trials was of very fine quality, and the process promises to be a success.

59. Economy in Fuel Consumption in Industrial Processes.

Coal may be used as fuel in three different forms—namely, in the raw state as *coal*, as *coke*, and as *gas*. Each has its advantages; but of the three forms the first, *i.e.* in the raw state, is the most expensive and wasteful, because all the volatile constituents of the fuel, and therefore the most valuable part, are almost entirely lost, being allowed to escape with the smoke—which latter must also be considered as waste, as smoke consists largely of unburnt coal or soot. Not only when raw coal is employed directly as fuel are most of the volatile constituents lost, but also in the manufacture of *coke* by heating coal, the gases thereby evolved are, strangely unscientific as it is, allowed to escape. As at the present time about eighty millions of tons of raw coal are consumed in this country, three-quarters of which might have its volatile constituents saved, it is calculated that over £17,250,000 represents the commercial value of the volatile constituents wasted. Recent research has done much towards saving this enormous national waste. When coal is distilled the residue in the retort is almost pure carbon or coke; this form of fuel being specially manufactured for use in the iron and other industries, for which it is better suited than raw coal. Now, except in a few instances where modern processes of recovery have been adopted, the volatile constituents of the whole of the 20,000,000 tons of coal annually coked in this country are allowed to escape into the air. Several processes, more or less successful, have been adopted for the recovery of the whole of these valuable products; chiefly by the use of close ovens in coking. We need only refer here to the exceedingly simple method generally known as the Jameson process, which may be adopted without replacing the old coking ovens, but simply slightly altering them—the alterations costing from £15 to £20 per oven. In the floor of the common coke oven are inserted two perforated iron pipes connected with an exhauster, or the brick floors of the coke ovens themselves are perforated, and the perforations connected with an exhauster, for applying a slight *suction*. When suction is applied through the main pipe connected with these perforations, the gases and volatile constituents given off from the coal during coking are continually but gently *drawn off* at the moment they are evolved. The drawn-off gases now pass through the main into a *condenser*, which consists simply of a series of cast-iron pipes exposed to the cooling action either of water or of the atmosphere, and the pipes in some cases provided internally with a stream of clean water for washing the gases. The gases after passing through these condensers, being now free from their condensable constituents, pass through the chamber containing the revolving fan or exhauster, and may be laid away and used either for generating the steam used in working the fan, or be applied to ay othern purpose desired. The liquid obtained from the condensers is run into tanks and allowed to stand for some time, to allow the crude oil and ammoniacal liquor to arrange themselves into two distinct liquors, whence they may be separated. In a future "note" *we will further treat this subject.*

60. Facts and Figures connected with Ventilation of Rooms.

(a) The number of inspirations and respirations, or "breaths" as they are popularly called, may be estimated at twenty per minute as a maximum, at sixteen as a minimum. (b) The volume or quantity expelled at each respiration from the lungs may be taken as forty cubic inches for a maximum, and thirty as a minimum. As it is safer to give a wide margin in practice, the maximum volume may be taken which gives twenty-eight cubic feet of air expelled from the lungs per hour. This would require a like volume of fresh or pure air to take its place. (c) Pure or fresh air, as it is generally called, consists of oxygen, which is equal to one-fifth of any given volume, and of nitrogen, which occupies the remaining four-fifths of the volume—less some ·04 per cent. of carbonic acid. On being expelled from the lungs, the chemical changes taking place increase the amount of carbonic acid gas, which our readers are aware is a poisonous gas that destroys life, to 4·6 per cent. (d) Of the gases constituting pure or fresh air, inhaled by or drawn into the lungs at each inspiration, and which are contained in, say the minimum cubic bulk of 488·16 cubic inches, it has been calculated that of oxygen there is inhaled 97·59 cubic inches; of nitrogen, 390·37, and of carbonic acid, 0·19. When exhaled or expelled from the lungs—respired—the volumes are changed respectively thus: oxygen, 77·19; nitrogen, the same; carbonic acid, 20·59. (e) But the carbonic acid gas formed by the act of breathing is not, as in the early days of sanitary science was thought, the only cause of the deterioration of air, rendering it unfitted for being breathed over again. For along with the air thus vitiated, as above, there is a certain amount of moisture exhaled from the lungs, this amounting to as much as will saturate seven pounds of air at 62° Fahr.; and allowing half saturation only to be carried out, this will require 187 cubic feet of air to be allowed for, which, added to the 28 cubic feet previously stated, taking the maximum in (b), gives 215 cubic feet of air, which requires to be changed, in an inhabited room, each hour. (f) But in addition to the mere chemical vitiation, so called, of the air by breathing, and by the moisture which air contains, it carries with it organic matter of a highly offensive and dangerous kind, tending still further to render the air impure. (g) Again, the air vitiated by gas or candles must be allowed for; so that at least 400 cubic feet of air per hour must be changed per head.

61. Data for estimating the Feeding Value of Farm Produce for Live Stock.

While authorities agree that as a general rule the feeding value of farm produce is indicated by the percentage of the constituents named in the column marked (1) in the table given below, practical men are well aware that there are various circumstances connected not only with the foods themselves on which the live stock are fed, but with the animals themselves, and the conditions under which they are kept, which exercise a modifying influence on what may be called the theoretical or chemical value of the food. While, therefore, the flesh-forming, otherwise called the albuminous, protein, or nitrogenous constituents, are first looked to, in estimating the value of any given food (the higher the percentage of those, the higher—other things being equal—its feeding value), still the other constituents must be considered as well, also the conditions under which the animals are, and how they are fed. What the various points to be considered by the cattle feeder, the reader will find as fully discussed as their importance demands in the text in the series of papers entitled "The Grazier and Cattle Breeder." The numbers in the columns in this table now to be given, noting the constituents of that important section of cattle foods known as "roots," indicate as follows: (1) flesh-forming or albuminous or nitrogenous constituents; (2) non-nitrogenous, sometimes known as carbonaceous constituents, heat-giving or fat-producing; (3) water; (4) woody fibre; (5) ash or incombustible constituents, —the first, second, and fourth classes of constituents being known as combustible or capable of being consumed.

TABLE SHOWING FOOD VALUE OF ROOTS.

Name of Root.	(1)	(2)	(3)	(4)	(5)
Swedish turnips . .	1·44	5·93	89·40	2·54	0·628
White Globe do. . .	1·14	2·96	90·43	1·02	1·02
Mangold wurtzel . .	1·54	8·60	87·78	1·12	0·96
Beet root	1·00	14·00	81·5	1·3	0·8
Kohl rabi	1·6	7·3	87·0	1·1	1·0
Potatoes	2·0	19·6	75·0	1·3	0·9
Jerusalem artichokes	2·0	13·8	80·0	1·3	1·1
Carrots	1·5	7·4	85·0	1·7	1·0
Parsnips	1·6	7·24	88·3	1·1	0·7

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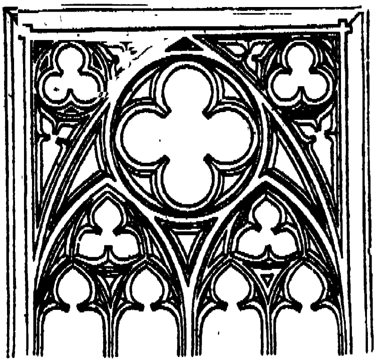
(18) In Note No. 12, while considering the subject of "steam raising," the "evaporation or boiling of water," we gave a brief glance at the leading physical or mechanical characteristics of water, the agent by which, in conjunction with heat, the producer of fuel combustion (see Note 14), steam is raised, and which liquid, used as it is in a vast variety of industrial processes in which heat is employed, gives to the boiling or evaporation even a wider interest and a more extended practical value than if it were confined to the department of industrial work known as the raising of steam for motive-power purposes. The points, however, which we now proceed to place before our readers on the general subject will apply equally well to the practice of boiling or evaporating in general industrial work, and to steam engine boiler practice in the raising of steam. At the end of par. 11 we described the operation of boiling as the creation of mechanical force or power. To such of our young readers as may have a difficulty to realise at first sight the fact that this is so, more than one simple experiment will easily be within their reach to give them ocular demonstration of the fact. Take a new and clean tin pan, such as that for boiling eggs —it can be bought for a penny at one of those "cheap shops" met with nearly everywhere—fill it with cold water within a quarter of an inch of the edge; place within it a few small pith balls, or few grains of some light-coloured substance which floats easily. Place the pan thus prepared on a trivet hooked on to the front bar of the grate, so that the heat of the fire will strike the inner and one side only of the pan. In a few minutes—more or less according to the heat of the fire and the quantity of water in the pan—a number of clear, shining, hemispherical globules will be seen lining the clear, shining bottom of the tin pan. After a little while the pith balls or floating substances will be seen to begin to move, and gradually assume a gyrating or circular movement round the water, approaching the heated side next the fire, and as the heat increases repelled from this part, and again resuming their circular motion round the water. Now, as will be seen from the paper in the text, "The Student's Introduction to the Principles of Mechanics," it is an established axiom in physics that there can be no motion without force. Now, that there is motion in the water is made clear to the eye by the movement of the pith balls; and as there was no movement of these when the pan was away from the fire and at rest, for this began only when placed within the influence of the fire, it must have been the heat of the latter which caused the motion. If the pan were withdrawn from the fire, as the water gradually cooled the motion would gradually cease, the force being withdrawn. While the water in the pan was gradually getting hotter, it would be noticed that the space it occupied was increased, for it would be observed that it had "swelled out" so as nearly to fill up the pan. This was due to a repulsion between the particles of the water caused by the heat, while the bright, clear, shining semi-globules at the bottom of the pan would be detached from it, rise upwards, and, darting to the surface, break through this as bubbles of air. Take now the pan from off the trivet, and place it in a hot part of the fire. The heat attacking, so to say, the whole surface of the bottom of the pan, and passing up the sides all round, the water will begin to take up the increments of heat so rapidly that ebullition or boiling will commence, with a violent agitation of the water; the steam bubbles rising rapidly and bursting through the water surface. That this ebullition is accompanied with force will be made evident if the outer end of the pan handle be touched with the finger, a series of shocks being felt. And should the pan be very nicely balanced on the coals, the motion induced by the force will be manifested by the pan vibrating or shaking; and this may be so pronounced that one bump more forcible than another may shake it from its seat. Those "bumps' or shocks generally accompanying constrained boiling, in which the vapour has difficulty in rising through and escaping from the water, are well known to laboratory experimenters, and the great object in boiling on the large scale is to make ebullition as free as possible, so that the vapour can escape easily from the water, thus avoiding the bumps and shocks, which represent just so much loss of economical boiling. Recent discoveries have explained the true nature of boiling, and a theory is based upon them which leads to a practice which will revolutionise the art of boiling and evaporation, which form so important a part of industrial work, not the least valuable department being that of steam raising. What the new theory is will be explained in a succeeding note, preliminary to which we have to explain phenomena connected with boiling not yet glanced at.

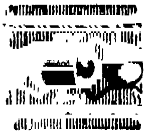
(19) In a preceding note on "Fuel and its combustion" we have said that "combustion" simply defined is the combination of the oxygen, one of the

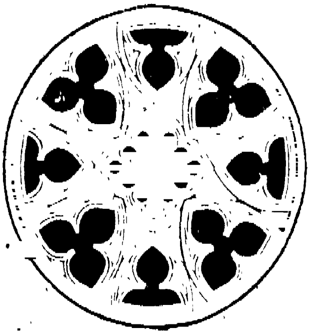
constituents of the ordinary air or atmosphere, with the constituents of the fuel under the influence of heat. But the air must itself be heated to the temperature suited for the fuel before the combination is effected and what is called combustion takes place; the temperature for coal being, on the average, 617° F. Many simple experiments will show the influence of air heated to a high temperature in promoting combustion, and in some instances creating it, as many must have observed that a combustible substance will take fire and burst into a blaze, through being simply exposed to the influence of air heated to a high temperature. It is not therefore necessary, as is popularly supposed, that a lighted body—that is, a combustible in such active combustion as to produce flame—should be employed before another combustible can be set on fire, kindled, or put into a condition of combustion. It is only a matter of convenience that setting fire to a combustible in the first instance is effected by means of another combustible in a state of flame. And as combustibles, of which there is an exceedingly wide range, have different "kindling points," (to coin an expression,) or points at which they will start into flame on the application of heat, and as some require but a low temperature, these substances are used as kindling materials in order to start the combustion of fuel which demands a comparatively high temperature before the combustion of oxygen with its constituents will create what is called combustion in more familiar terms, set it on fire. The heavier and denser or more solid and heavy the natural or normal condition of a combustible used as a fuel is for a wide range of substances are combustible which are not classed as fuels—the more difficult it is to set on fire. Light and porous combustible substances, presenting large surfaces in proportion to their weight, are therefore used as fire kindlers in ordinary work, and these are met with in paper and small pieces of wood. In the kindling of a common kitchen fire all the points connected with fuel and its combustion are familiarly illustrated. In this the combustibles are placed in the grate in the following order: first the paper, above this the pieces of wood, and finally as the top layer the coals. The paper having a high point or order of "ready inflammability," so to call it, requires but few increments of heat—so low a temperature to make it combine with the oxygen to create combustion that the application for a second or two of a lighted match suffices to set it on fire. The heat increments thus created are in turn sufficient to raise the temperature of the wood and oxygen required to set the pieces on fire, and this in turn creates a temperature sufficiently high to effect the combination between the constituents of the coal and the oxygen of the air entering the fire grate till the coal is at last set fire to. We say "at last," for the combination requisite to create perfect combustion is not immediate, nor indeed in practice even very rapid. Time in all cases is required; the fuel demands, so to say, a kind of preparation before good and efficient heat-giving combustion is secured—what a high practical authority terms a species of cooking.

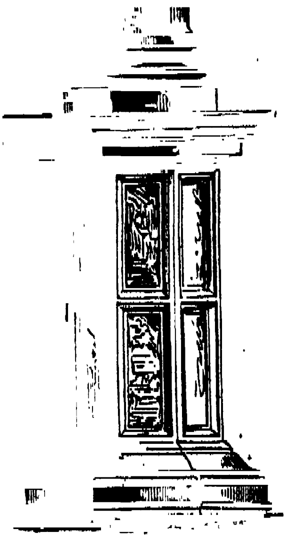
(20) Under the head of "Cements" (see Nos. 9 and 10) we give the method of making the celebrated cement known as "white Russian glue." One hundred parts of the finest glue are melted in the same quantity of water under the influence of a gentle heat long continued rather than of one of greater temperature for a shorter time, as this latter would evaporate the water before it did its office of melting—a practical point often neglected in the melting or softening of glues and gums. Then to the melted glue add five or six parts of nitric acid, known as aquafortis popularly; and when this is added, stir carefully and thoroughly into the mixture six parts of powdered sulphate of lead.

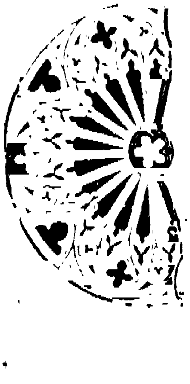
(21) Under the same head we give a note on liquid glues. These glues are possessed of this advantage, that they do not "set" or harden when they become cold; consequently they can be used at once without being heated—a great convenience in working. The principle upon which liquid glues are made is the employment of some acid liquid, such as nitric acid or acetic acid, applied cold; or for the latter strong good vinegar, if more conveniently had, may be substituted, but this is applied hot in melting the glue for the first time. The office the acid fulfils is in dissolving the gelatine in the glue and imparting to it the property of remaining in solution, and this without destroying or even lessening its adhesive or stick-fast quality. There are various ways of making liquid glue. One is this: A convenient weight of the best glue is dissolved under the action of heat in an equal weight of strong vinegar; or a less proportion of acetic acid or very strong acid, with which many so-called vinegars for domestic purposes are made, without, it need scarcely be said, however, the fine flavour of vinegar made from malt or fruit. When the glue is dissolved, add a fourth part of the weight of the glue of spirits of wine, together with a small portion of alum crushed into powder. This glue, which is highly spoken of, should be kept in closely corked bottles in jars. In all cements the basis of which is glue or gum arabic the best results can only be obtained by, in the first instance, melting the glue or gum under the influence of heat gently applied. The melting is not only done more quickly, but its adhesive "stick-fast" qualities are better developed than when cold melting or dissolving is resorted to for the saving of trouble.

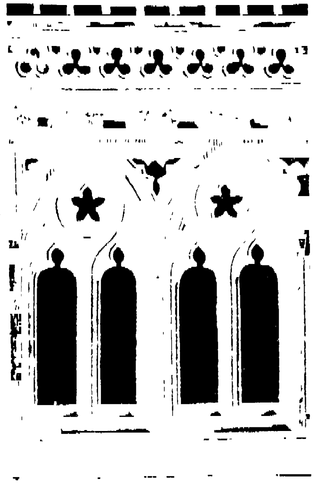


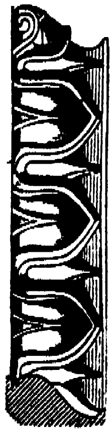


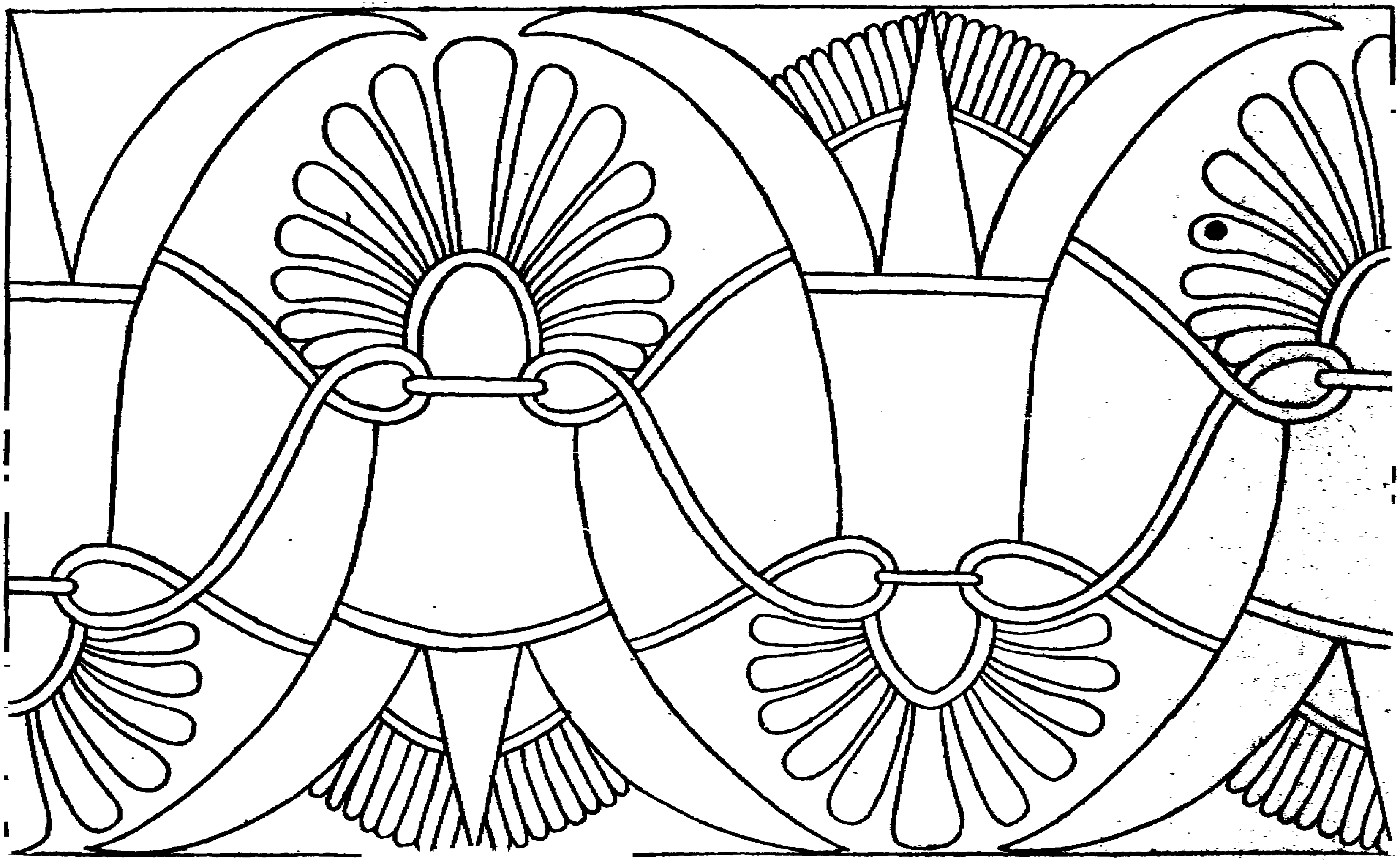




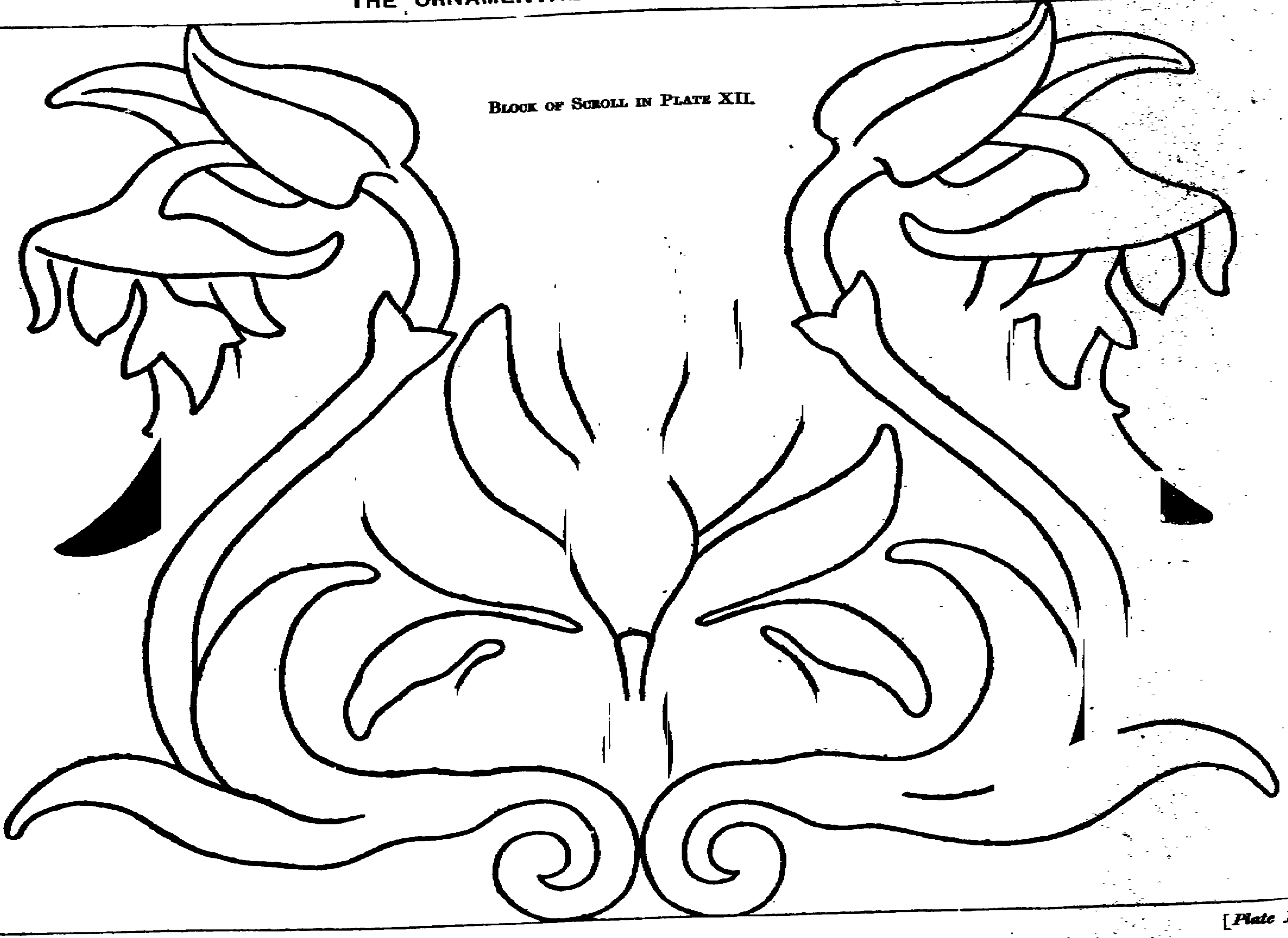








BLOCK OF SCROLL IN PLATE XII.



THE JOINER (8
DETAILS OF WINDOW CONSTRUCTION.

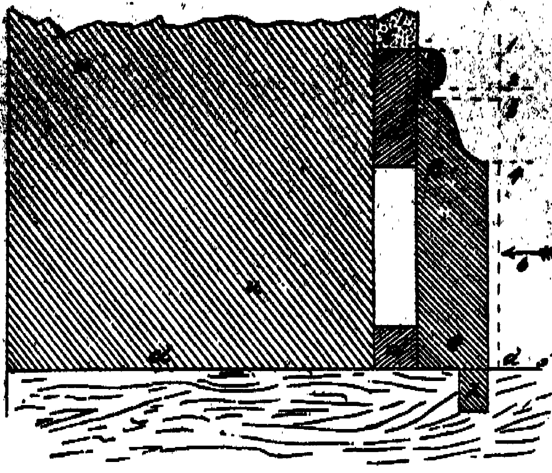


Fig. 1.

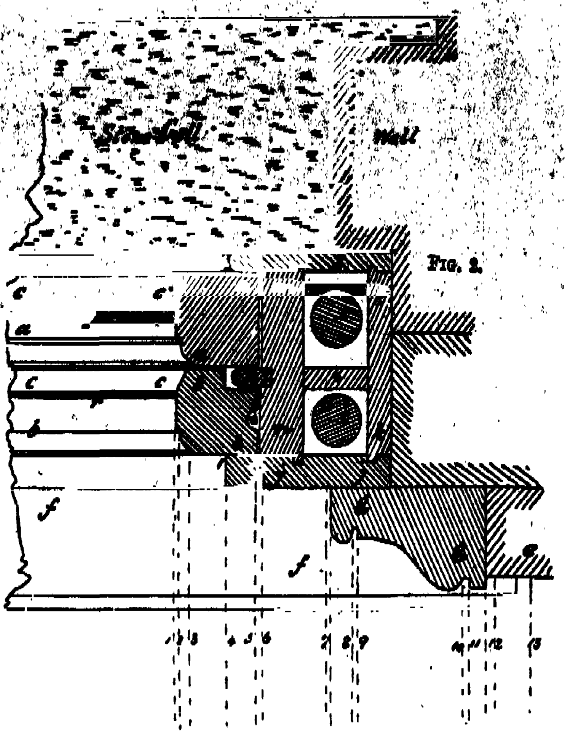


Fig. 2.

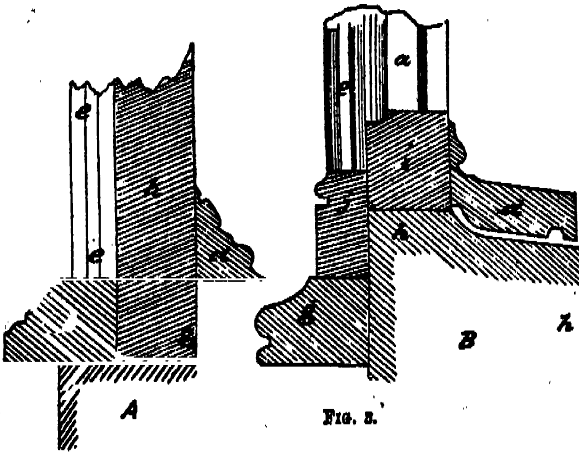


Fig. 3.

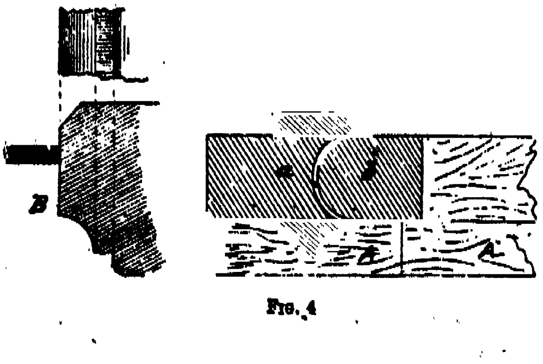


Fig. 4

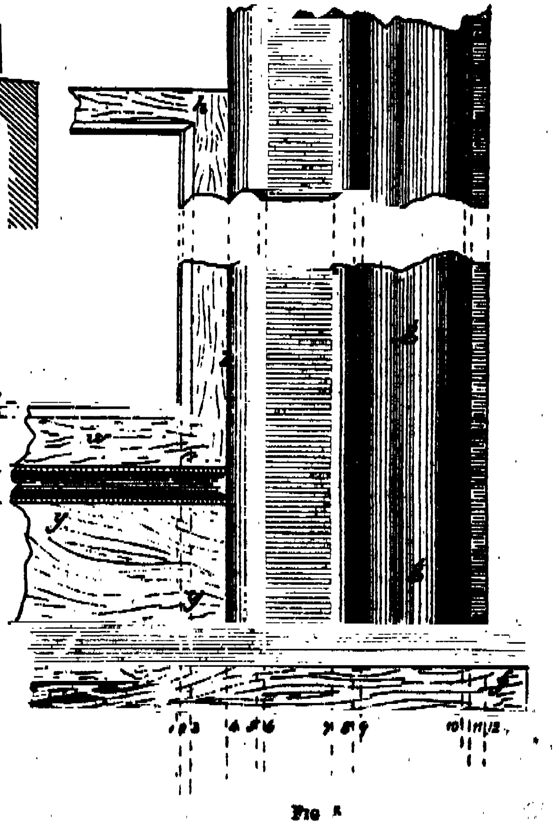
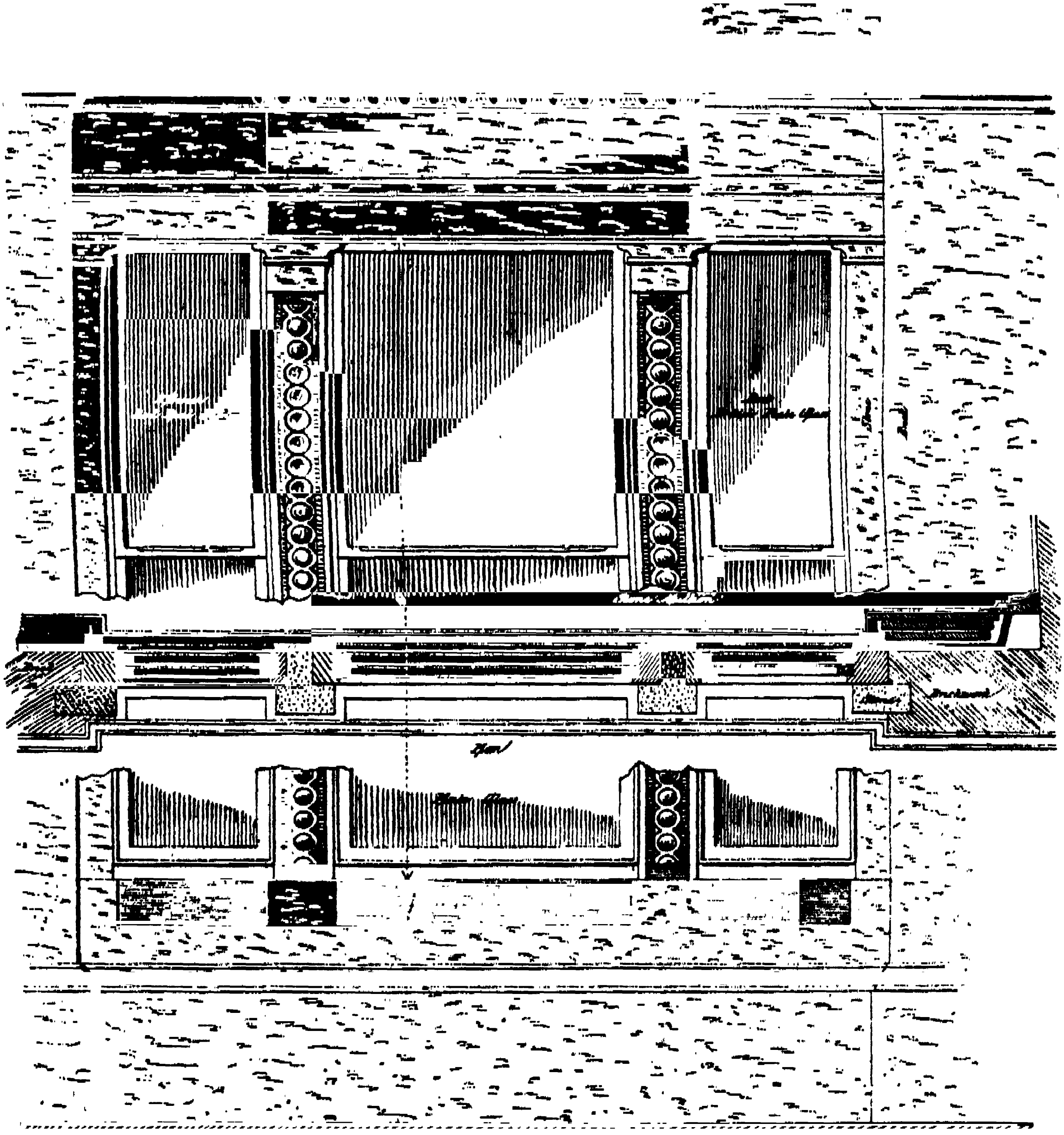


Fig 5

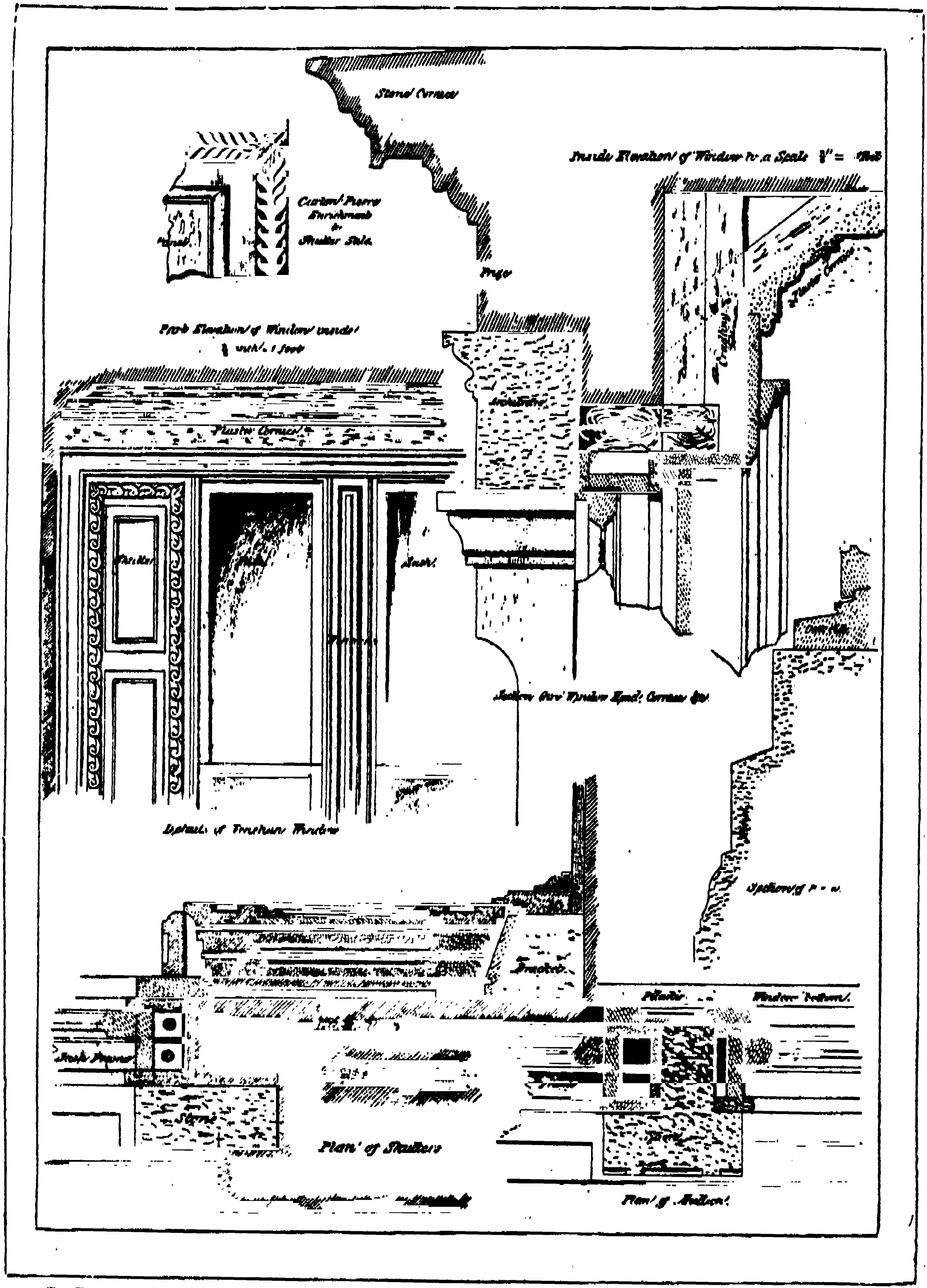
Part Elevation and



[Plate LIII.

THE STONE MASON AND THE JOINER (see Text).

DETAILS OF VENETIAN WINDOW IN PLATE LIII.



Stone Cornice
Carved Pearl Enrichment to Shutter Stile
Panel
Frieze
Inside Elevation of Window to a Scale ⅛" = 1 foot
Plaster Cornice
Part Elevation of Window inside ½ inch = 1 foot
Plaster Cornice
Architrave
Shutter
Sash
Section thro' Window Head, Cornice &c.
Details of Venetian Window
Section of P – w
Bracket
Back Flap
Stone
Plan of Shutters
Pilaster
Window Bottom
Stone
Plan of Mullion

Bevel Toothed Wheel Gearing. One-Sixth Full Size (2" = 1 Foot).

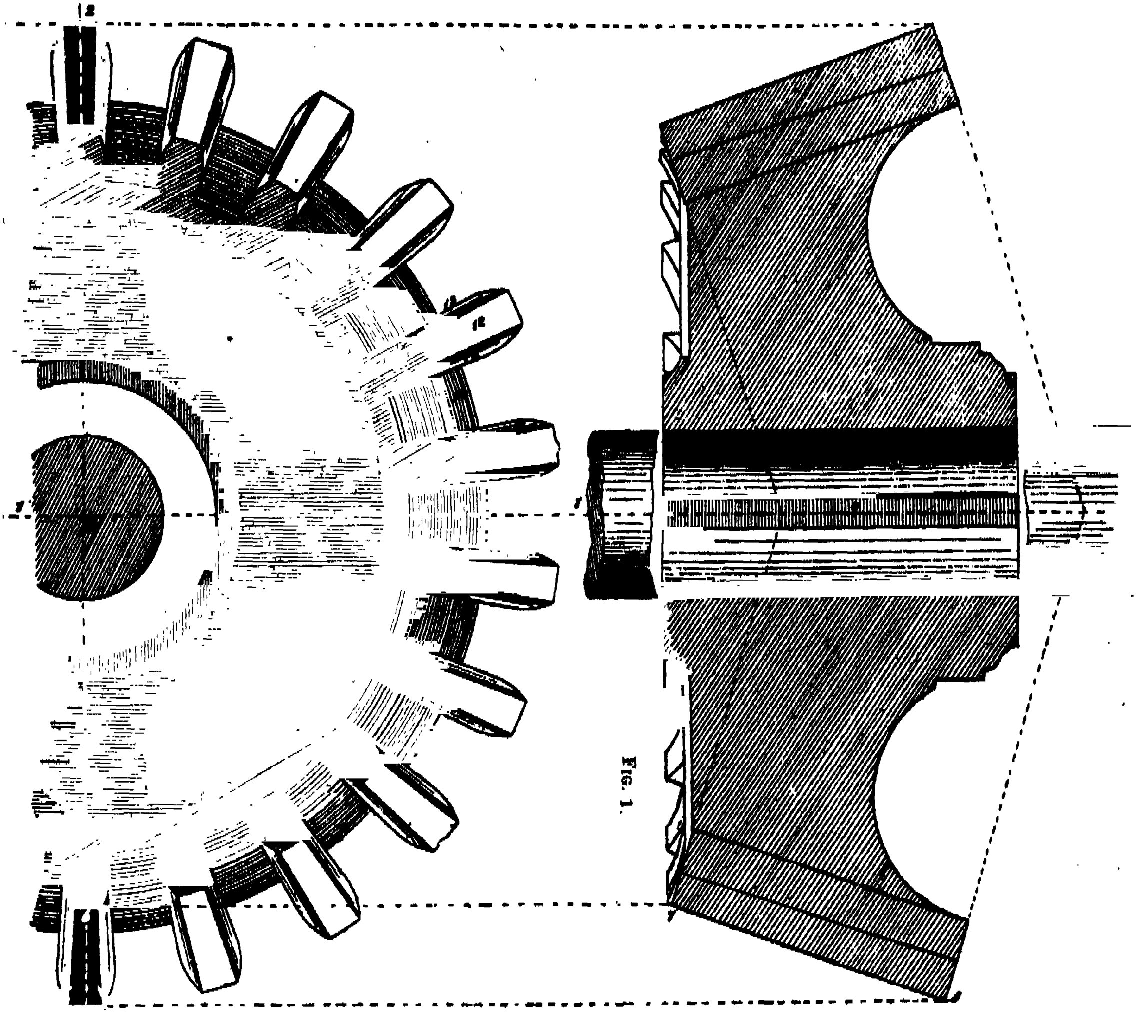


Fig. 1.

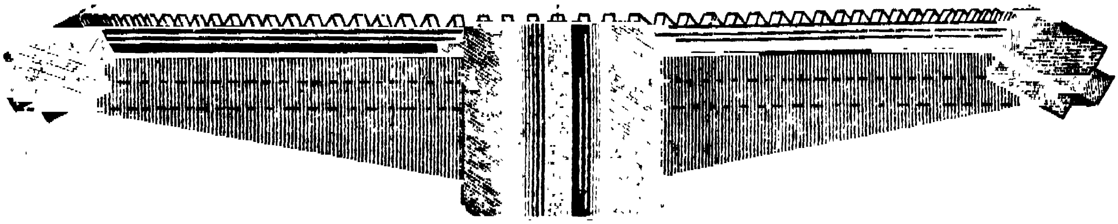


Fig. 8.

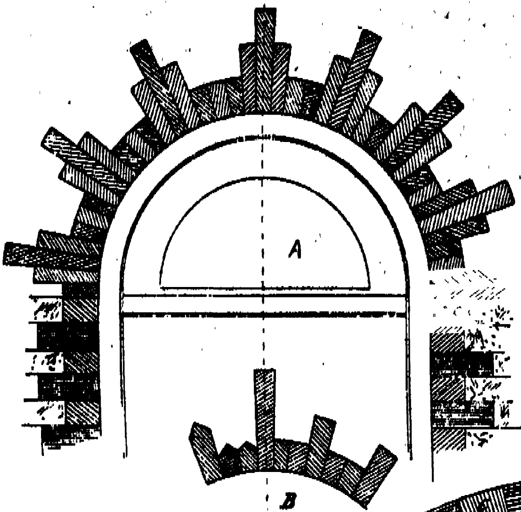


Fig. 1.

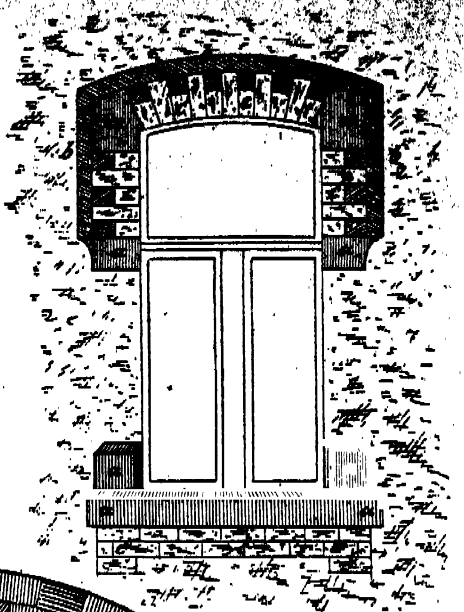


Fig. 2.

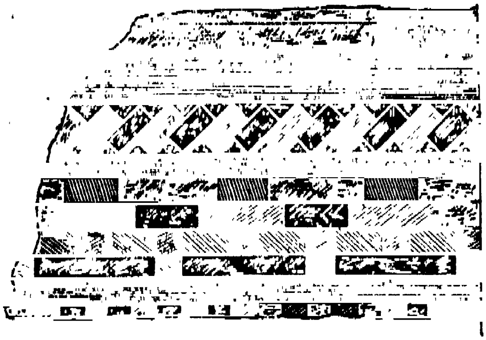


Fig. 3.

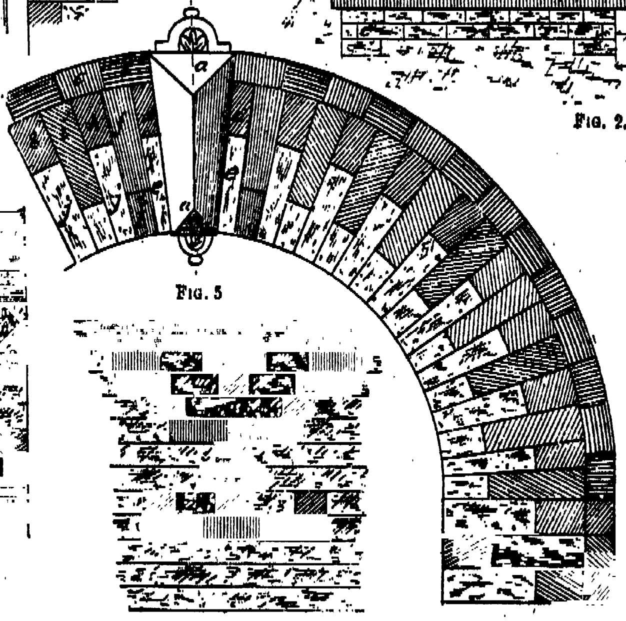


Fig. 5

Fig. 4.

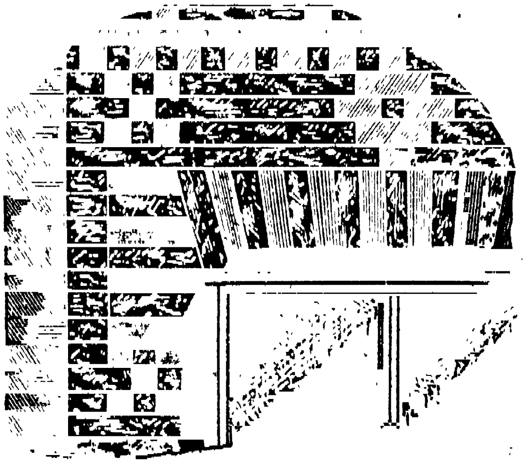


Fig. 6.

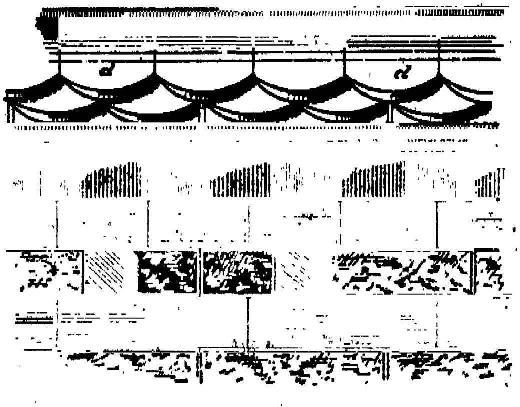


Fig. 7.

THE ROAD MAKER.

HIS WORK IN THE LAYING OUT OF ROADS IN RURAL, SUBURBAN AND TOWN DISTRICTS, THEIR CONSTRUCTION, REPAIR, AND IN THE CHOICE AND USE OF THE VARIOUS MATERIALS EMPLOYED.

CHAPTER II.

The Cross Section or Lateral Form of a Road Surface.—Equal Distribution of the Load in a Carriage.

AFTER having determined upon the direction and breadth of a road, the next matter for the consideration of a road maker is the lateral form of the surface of the road he is about to construct. In road making, as in every other undertaking, of the many modes of doing it we see practised, there can but be *one right way.* All others must of necessity be *wrong,* as there can be only one way of securing perfection, if that be ever attained. A road cannot be too flat and level in the lateral form of its surface, for the reasons about to be adduced. It is only upon a surface that is laterally flat and level that wheel-carriages can sustain *an equal portion of the load on the wheels on each side*; and hence it is that the sides of roads of considerable lateral convexity of surface are as much as possible avoided, and the crown of the convexity being the only part of the surface on which the wheels can have an equal bearing on each side, it is there that a road is exposed to undue traffic, and is soonest worn.

Stability of Loaded Carriages affected by the Cross Section or Lateral Surfaces of Roads.—Conditions favourable to an Overturn.

The centre of gravity, or point of concentration of the weight of a carriage and its load, is displaced an equal distance from each side when the carriage is travelling upon a laterally inclined surface; and hence the tendency of the carriage to overturn to the lower side. The danger is increased first by the greater the velocity of the motion of the carriage; second, by the greater the height of the centre of gravity of the load from the ground; third, by the smaller the distance between the bearing of the wheels; and fourth, by the actual shifting of a loose load to the lower side. A vehicle at rest containing a solid mass, as a single block of stone or metal, the carriage being perfectly hard in its construction, and having a wide bearing between its wheels on each side, may stand, it is true, upon a very considerable lateral declivity without danger of overturning. But let the carriage be elastic in its construction, have considerable velocity of motion with a loose or shifting load, then its going across a very trifling declivity will be attended with danger of its overturning; and the danger will be increased with every increase of the conditions above mentioned as favourable to an overturn, or as it may otherwise be put, unfavourable to stability.

In a body at rest upon an inclined plane, so long as a vertical line passing through its centre of gravity meets the surface of the plane within the base of the body, the body will not fall over without some force being exerted against it. When the vertical line passing through the centre of gravity meets the plane at the extremity of the base of the body, the body will then be *in equilibrio* between standing and falling. And when the vertical line passing through the centre of gravity meets the plane beyond the base of the body, the body cannot stand, but will fall over without any force being exerted against it to overturn it. The degree of lateral declivity on which carriages may stand at rest, or even move at a moderate velocity with safety, may be calculated with accuracy by a rule which will be hereafter given; but in the case of carriages moving at a great speed, and under the other conditions already named as being favourable to an overturn, it is difficult, from the uncertain nature of the causes, to make due allowance for their influence as regards unsafety. It is, therefore, most important that great lateral convexity in the form of roads should be scrupulously avoided. (For the various points connected with the "centre of gravity" and the stability of structures, the reader is referred to the papers given under the head of "The Technical Workman as a Student of the Principles of Mechanics.")

Flat and Round or Convex Surface Roads.

Notwithstanding the cogent, and at the same time obvious reasons adduced for the lateral form of the surface of roads being flat, yet an unnecessary and dangerous convexity seems to be the general rule in road making. The only reason of any degree of plausibility advanced for the practice is that this convexity keeps the surface dry, and thereby the better keeps the road longer in repair. If, however, the water which renders the roads wet were clean, a very trifling degree of convexity would be sufficient to allow it to run off a road. But it happens that the cause of wetness of roads, in most cases, is thick mud, in which scarcely any degree of practicable convexity will produce motion. So far from the end expected being attained, the means taken is, perhaps, of all others that might be adopted, not only the least likely to be successful, but most calculated to defeat the purpose intended.

By reason of great convexity in the lateral form of surface of a road, an undue portion of the traffic upon it is brought on to its crown for the reason above stated, by which that portion of the breadth is rapidly worn into longitudinal ruts for holding water, to the utter destruction of the road. When traffic comes on to the sides of a road the injury is always much more extensive on an inclined plane than on a level surface with the same amount of traffic, from an undue portion of the loads being thrown on the wheels on one side of the vehicles, instead of the whole load being equally distributed on the wheels on both sides, and the whole of the traffic being distributed over the whole breadth of the road, which it would be were the surface laterally level.

No tenable reason whatever can be adduced for any road having a greater convexity than a rise of six inches at the crown in a breadth of thirty feet, giving the sides a gradient of 1 in 30; and so in proportion for any other breadth. This would be sufficient to prevent a road from wearing hollow, and not so great as to be the occasion of the evils pointed out; amongst which the danger arising from over-convexity is so great and of such importance, that no advantage—either real or imaginary—can compensate for this form, if used.

To find the point on a laterally-inclined form of road, at which a vertical line passing through the centre of gravity of a loaded carriage will meet the surface.—Divide the height of the centre of gravity from the surface of the road by the gradient, or distance required for a height of 1 of the incline, and the quotient will be the distance from the mid-distance between the wheels on each side of the carriage to the point at which the vertical line passing through the centre of gravity will meet the surface of the road.

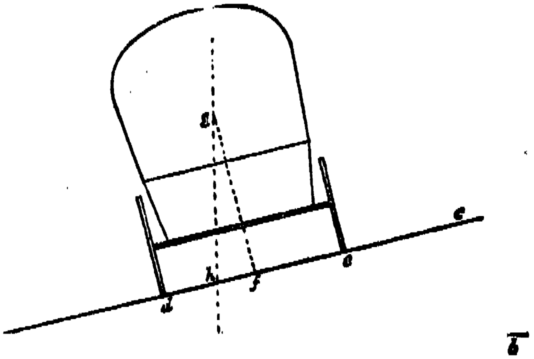


Fig. 2.

The foregoing rule of computation will be better understood by inspection of the diagram above, representing the transverse section of a loaded carriage on an incline of the lateral form of the surface of a road, in which *a b*, fig. 2, is the horizon, *a c* the incline of the surface, *d* and *e* the wheels at each side of the carriage, *f* the mid-distance between the wheels, *g* the centre of gravity of the carriage and its load, *f g* the height of the centre of gravity above the surface of the road, *g h* the vertical line passing through the centre of gravity, *h* the point at which such line meets the incline of the surface of the road, and *h f* its distance from the mid-distance between the wheels.

Whilst *h f* is less than *f d*, the carriage, whilst at rest or moving with a moderate velocity, will not overturn without some force being exerted against it: but the nearer the point *h* approaches to *d*, the less will be the force required to upset the carriage.

The Portion of the Load borne by the Wheels on either side of a Carriage travelling on a Laterally-inclined Road

is reciprocally as the distances *d h* and *h e*, and may be found by multiplying the whole load by the distance *h e*, the product of which divided by the distance *d e*, the quotient will be the portion of the load sustained by the lower wheel *d*, and the remainder on the weight sustained by the wheel *d* subtracted from the whole load will be the weight borne on the wheel *e* on the higher level of the incline. The following are examples of the above:—

Required the distance from mid-distance between the wheels of a carriage, the height of the centre of gravity of which and its load is 6 feet from the surface of a road inclined laterally at the rate of 1 in 9, that a vertical line passing through the centre of gravity will meet the surface of the road.

The quotient of 6 feet, the height of the centre of gravity, divided by 9, the gradient of the incline of the road, is ·6′ or 8 inches, the distance from the mid-distance between the wheels towards the wheel on the lower level of the incline.

What portion of a load of 30 cwt., including the weight of a cart, will the wheel on the lower level of incline of the gradient as in the last example have to sustain, the distance between the wheels being 4 feet 6 inches, and the height of the centre of gravity being 6 feet?

Half of 4 feet 6 inches is 2 feet 3 inches, the sum of which added to 8 inches, the result of the last example, and which is the distance *e h*, fig. 2, is 2 feet 11 inches. The product, 30 cwt., multiplied by 2 feet 11 inches, or 2·916′, is 87·5, and this divided by 4 feet 6 inches, or 4·5, is 17·2 cwt., the portion of the load borne by the wheel on the lower level of the incline, leaving 12·7 cwt. to be sustained by the wheel on the higher level of the incline.

The Construction of Roads: their Proper Form or Cross Section.

When treating of the proper lateral form of the surface of a road when finished, the necessity of such surface being nearly flat was pointed out; and it was stated that a rise of six inches at the crown of a road thirty feet in breadth would be amply sufficient to prevent its becoming hollow, and that no danger would arise from such convexity. But as it may be necessary for the covering of a road to be somewhat stronger in the middle than at the sides, the form of the surfaces of the soil should not have quite the same amount of convexity as the road when completed with its covering. A convexity produced by a rise of four and a half inches at the crown, for a road thirty feet in breadth, will therefore be sufficient previously to the covering being upon it.

THE FARMER AS A TECHNICAL WORKMAN.

HIS TOOLS, IMPLEMENTS, MACHINES AND MATERIALS. —THE PRINCIPLES OF HIS WORK IN ITS VARIOUS DEPARTMENTS.

CHAPTER II.

WE concluded the preceding chapter by stating that to aid the farm labourer to rise in the exercise of his calling to steadily improving positions, every social and educational help was placed within his reach. And this may be said with all confidence; for facts go to prove it, no matter what assertions which are not facts may be brought forward to the contrary. But on this point we feel assured that our readers will be at one with us. In concluding these introductory remarks, which are intended to convey, as we believe they do, truths and principles of action of practical value to our readers, we trust that in what we are to present to them bearing on essential points—the technical work of farming,—they will find something which, applied to the work of its daily life, will tend somewhat to help them in securing its success.

Brief Glance at the Special Features of Farming—Its Relation to General Science.

Before entering into a duly arranged and detailed statement of the various points of the subject, we shall, as introductory to this and as tending to show the relationship subsisting between the various departments of farming, take a brief glance at the subject as a whole. In this glance or general *résumé* we shall frequently use the term "science," the science of agriculture or of farming; and this more on the score of convenience, seeing that it has become an established phrase, than from the fact that it sets aside the expression "technical work," which we have hitherto used. It does not set it aside: it on the contrary rather endorses or enforces it; for tracing terms to their source, and arriving at the ultimate result, we find that to be—what it has been defined in the papers on "The Workman as a Technical Student" to be—work, technical work, to be done, showing that our title in no sense degrades farming as a work to be done. In so far separating, as some may think it does separate it, from what claims to be a science, we have had occasion to remark that if the practical work of farming is distinguished by any one thing in particular, it is so from the intimate relation which science bears to it. It may indeed be said with perfect truth that there exists no branch of those industries which have contributed, and still contribute, so much to the well-being and the social prosperity of the people, which has received greater aid from a number of sciences than has farming. So marked, indeed, has this been during at least the last half-century, and so decided in character has been the connection between the farm and the study of the scientific man, that farming can lay a most certain claim to be considered a science as well as art, using here the popular term, and as carrying the popular acceptation—a calling in which something must be known as well as that which has to be done; daily displaying some new developments, and adding, and likely more and more to add, to the material resources of the nation in the all-important, because essential, department of the production of foods of various kinds. It is not that this marvellous improvement has taken place because the principles of the art have been changed; these, being founded on natural laws which are unvarying in their operation, are not found to vary themselves. It is rather in the application of new methods of working, and in the adaptation of a wide range of mechanical appliances and materials, which no one thought at one time at all applicable to an art that for so long was considered independent of all such aids as farming was deemed to be. To trace the causes which brought about the peculiar circumstances in the material aspects of farming that made these new appliances of value, or of their being so modified as to give them a chance of being easily applied; to point out the modifying influences of soil, climate, and locality, and to show how those necessitated a difference in one place from the practice which characterised that of another—a difference which has greatly puzzled many not acquainted with the inner developments of farming—and to show how one improvement in the cultural department necessitated and brought about a change or improvement in the materials and appliances by which this department was aided; and lastly, to place before the reader a fairly exhaustive and assuredly a trustworthy photograph—if such a term be allowable,—showing the latest stage at which farming has arrived, is the task we have set before us, and is the theme which will occupy these pages of the present series of chapters.

In proceeding with our remarks, it will be essential for those of our readers who are here assumed to have but little knowledge of the subject, to point out one feature which distinguishes it from nearly every other art or science which makes up that wide work of farming which we have already referred to, adding so largely to the material worth and social influence of our country. The point here alluded to is one very frequently overlooked by practical men connected with farming, so that those not immediately concerned in it may well be excused for ignorance of it. It may be simply stated thus.

Farming not a Fixed Science—Practice Modified by Various Circumstances, such as Varieties of Soils.

Farming is not a fixed science, with its elements influenced by and subjected to a law, or set of laws, unvarying in their operation, which can be calculated on, and from which certain results of given processes can be predicted with more or less distinctive accuracy. On the contrary, farming—or agriculture, to use the more popular and perhaps more elegant term—is a science which deals with materials of an exceedingly varied and constantly varying kind, and which are subjected to and influenced by elements which themselves possess the same characteristics of doubt and uncertainty. To use a mathematical phrase, farming as a science has very frequently to "deal with unknown quantities." She has not only to deal, for example, with certain substances, as seeds and manures, which under certain conditions yield certain results, but which under other conditions and circumstances yield results of a totally different character. And those substances, moreover, are frequently placed in conjunction with other substances, which themselves have their like varying characteristics, and are possessed of like influences; and the conjunction of those differing and different substances brings about certain results which differ or may differ materially from those brought about when one set only of substances is used in the like conditions. Again, the farmer, as in the case of the feeding and rearing of animals, has to do with life; and the peculiarities of this—which, as they vary with humanity, vary also in animals—and the way in which these peculiarities act with and upon and counteract the influence of foods—*qua*, or as foods only—give rise to the most complicated problems, which are not all as yet, if indeed they ever may be, solved. The very soil in which the farmer works varies so much, not merely showing different characteristics—as for example physical or mechanical—in different districts; but in the same districts, where uniformity in the soil might presumably be fairly expected, this uniformity is not to be met with. But more and still more puzzling in its effects to the farmer who has to deal with them, the soil even in the same field is not always uniform in its constituents,—far indeed from that. The practical outcome, then, of this particular condition of matters is that different soils demand different styles of treatment or methods of working, and these in turn differences in the details, if not in the principles—although sometimes even in these—of construction of the mechanical appliances used, and this often to such an extent that a much wider variety of them is required than would on first thoughts be deemed necessary.

Changing and Puzzling Circumstances connected with Soils, Manures, and Seeds, as modifying the Practice and influencing the Results of Farming.

But this variety in the methods of working the soil and in the appliances used in connection with them is not the only point which makes the practice of agriculture so markedly different from other branches of industry. There are other points still to be noticed. The soils, as we have seen, differing in constitution, not only demand different modes of mechanical treatment in order to prepare them for the reception of the seed and its after fructification, but those differences bring about effects which are at all times more or less troublesome, and, from the uncertainty connected with them, a variety of circumstances which are often extremely puzzling to the farmer, disabling him, so to say, from judging of the actual results of his operations. Thus, take the application of manures to land, to which we have already made the briefest of references. Presuming that the soil has been analysed and its constituents known—what it contains of those fertilising or otherwise, and in what it is deficient; and further, that the like knowledge is had of the seeds to be sown, their constituents, and what of the soil they withdraw from it, and how much of these,—one might fairly predicate that all these elements being known, certain results would be obtained. But while upon the whole certain manurial agents are known to produce certain cultural effects, these effects are exceedingly various in characteristics and proportions. Nay, more: the manure which upon the same soil, with the same seed, and—as far as human labour can be said to be at all times uniform, depending as it does upon the varying capabilities and determination of an individual—with the same kind of labour and treatment bestowed upon it, gives in one season certain results, does not in another give these in anything like the same proportion. But further, and still more puzzling and difficult to be accounted for, the results of one season are almost precisely opposite to those of another, although the circumstances of both have been, as far as one could judge, precisely of the same kind. And in addition to those circumstances connected with soils and seeds, and the action of manures upon both, there comes into play the operation of climate, locality, as regards exposure to certain winds, drought, or excess of moisture, and the like,—all of which, acting in ways for which if there be laws we know little or nothing of them, tend still further to throw round all agricultural operations such elements of doubt and uncertainty that the result of any experiment, or of the working of one season, cannot be positively accepted as a guide to or an index of what will be the result of those of another. That they are often taken to be such is true enough, but just so often as they are thoughtlessly taken to be guides—or what may be termed rules or laws—just so often is disappointment at results likely to arise. And, indeed, it is forgetfulness of the circumstances we have now alluded to which brings not merely disappointment to many farmers, with all their concurrent losses, but tends moreover to bring the whole work of farming into disrepute with the general public as a mere collection of confused risks.

THE STEEL MAKER.

THE DETAILS OF HIS WORK—THE PRINCIPLES OF ITS PROCESSES—THE QUALITIES AND CHARACTERISTICS OF ITS PRODUCTS.

CHAPTER II.

Definition of the Term "Steel"—Practical Importance of Accurate Definitions of Technical Materials and Work (*continued*).

AT the conclusion of the last chapter we stated under this head that the new metal was introduced to the trade as "steel." It may indeed be said with perfect accuracy, that had the new product been introduced to the trade by some other name, it would have taken a quicker hold of the mechanical mind. What that other name, in the opinions of scientific men, should have been, we shall hereafter briefly glance at. Let not the reader suppose that the mere name is a matter of no practical importance. On the contrary, a distinct name is essential for practical purposes, and for merely scientific purposes precise definition is no less so. We do not go into this further here, then, than by simply stating what is given by one authority engaged daily in the extensive manufacture of the new metal, and who also knows practically its uses, and who says that "the application of the term 'steel' to the newer classes of this metal was indeed unfortunate so far as makers were concerned, and has contributed not a little to the many difficulties they have experienced in the conduct of their business," and what has offered difficulties to the makers has also—although different in degree and kind—offered them to the users of the metals. It may be said that a definition of the new steel has been arrived at—one, moreover, which is by the consent of many engineers and mechanics accepted as correct. And it is also a simple one, the name meaning a metal, an alloy of iron which can be cast or moulded into a form to which the name of ingot is attached; this alloy or metal being malleable and capable of being rolled, hammered, or pressed into any shape or size desired. More restricted in terms, steel is defined to be that alloy of iron produced in a fused state by the "Bessemer" or "open-hearth" process of manufacture. But this apparently only removes the difficulty to a farther though more precise point than that hitherto arrived at; it does not get rid of it. We say apparently, for although quite ready to grant that this new product of new methods of manufacture is a new metal—which, indeed, even if they had a mind to, they cannot well deny—not a few of our most practical men are by no means disposed to admit that, although it is a new metal, it is steel.

What is Steel?—Various Practical Points involved in the Answer or Attempted Answer.

So curiously involved is the question, indeed, that, singularly enough, such practical authorities cannot assume this position, any more than their opponents can prove the accuracy of the above-named definition without doing the same thing. For both are compelled to put the old question, which, as yet at all events, revolves upon a centre, and like the curved line of a circle returns perpetually to itself, so that the same point is ever being reached, and this old question is just What *is* steel? If this new metal, the product of the melting process of the Bessemer converter, or of the open hearth, be, as it is said to be, a steel, is it a true steel, and is steel a metal which can be hardened and tempered and be made capable of producing a keen cutting edge? Hitherto a metal, the alloy of iron, which possesses these properties, has been by universal consensus defined as steel. But if so, then beyond all question the "mild steels"—another definition, by the way—produced by the Bessemer and open-hearth processes are not steel. For, as those practical men point out whom we have above alluded to as those who cannot accept the definition of steel we have above named as correct, it is a thoroughly difficult thing to say if those so-called mild steels are not in reality only superior wrought iron. Again and again has the statement been made by practical men, at the meetings of practical men, and made without contradiction—without any sign, indeed, that confutation was necessitated or could reasonably be made—that it was a very difficult thing indeed for even an expert in our constructive metals to say with precision, of two given metals, which was iron and which was steel. It is almost impossible to read a paper, or to listen to a discussion of even the most recent outcome of experience, without getting clear evidence of the fact that the whole subject bristles, so to say, with difficulties; giving rise to an almost endless variety of opinions, and showing the existence of points of difficulty so obscure, that all that is at present left for practical men to do, is to be content with conjectures and surmises, some of them the crudest and most undigested. And this eminently unsatisfactory condition is likely to remain so, at least for a time, till we learn more—and we are every day learning more and more—about the processes of manufacture carried out. For certain truths have been discussed, and certain conjectures proved almost to demonstration to be correct; still a limit must be placed to actual investigation—which alone can be productive of precise and definite results—when that is to be made within the interior of a blast furnace or a Bessemer converter. It is, indeed, one of the great advantages yielded by the open-hearth process, the great rival of at least the latter, that it affords facilities for watching the progress and for repeatedly testing the results of any process of metal manufacture carried on by its aid; although it is only right to state that, so far as affording facilities for testing the results at any time during the actual carrying out of the process, or "blow" as it is termed in Bessemer steel works, the Bessemer process has claimed for it a value at least quite equal to the open-hearth process. But as regards the facilities for watching the actualities of the process throughout, the reader who knows the features of both processes —which will be duly described hereafter—will, we think, give the precedence of position to that of the open hearth.

Further Practical Considerations connected with the Subject of the Definition of Steel.

Carefully noting, then, all these circumstances we have already named, and those others also which will be specifically referred to, or will incidently crop up in discussing other departments in chapters yet to follow, and which have also the closest bearing upon this important question, What is steel? would it not seem a better way to arrive at its determination in some mode different from that attempted? The point is well worthy of earnest consideration, for the question is not merely one of theoretical value, its determination not only one of business convenience, but, as all scientific men well know, the answer to the question involves points of the greatest scientific importance, bearing in the closest way upon practical work. Would it not, then, be well to decide upon a double definition, so to call it, which will embrace the two metals, or rather distinctly separate them and keep them apart? The two names seem to be already at hand. Let "steel" be only and always applied to that metal or alloy of iron which has hitherto been known by this title, and which alone has the distinctive characteristics of being able to be hardened and tempered—characteristics which, till within recent times, have been universally accepted as those only of the metal or alloy of iron popularly or generally called steel. On the other hand, let the new metal, the product of these processes—of which the Bessemer converter and the open hearth are the representative, if they be not, as indeed they practically are, the only two methods by which this alloy of iron can be cast into moulds or ingots, and afterwards pressed or rolled or hammered—have its own distinctive name. As we have said, the name is already at hand, and is indeed extensively if not universally used—"ingot steel." Or if another distinctive characteristic be considered the best basis for a new name to the new metal, take the proposal of Sir Joseph Whitworth, and let all metals possessing a tensile strength *below* a certain agreed-upon point be called irons—all metals possessing a tensile strength *above* it be called steels. The name ingot steel is perhaps the simpler of the two; at all events it carries with it no inherent difficulty, as it is already accepted as defining a certain product, and does not, at least it has not yet acted, as an incentive to that combative faculty which engineers and mechanics, if they have, as we believe they have, less of in scientific and practical points than the members of other professions, are certainly not altogether deficient in. For this combative faculty would be aroused—has already, indeed, been so—in the attempt to agree upon the point what *is* the line of tensile strength which below it would cause a metal to be defined as "iron," but if above it would give to it the name of "steel"? But whether such a way to get out of the difficulty here quietly and with diffidence suggested be adopted or not, or whether some modification of its distinctive character be preferred, certainly it seems that the state of uncertainty which characterises the question as it now stands is not to the credit of engineers and mechanics, assuredly not worthy of the science of metallurgy—a science which of late years, in absolutely revolutionising the manufacture of iron (using the term in its broadest acceptation as embracing all its alloys) has increased to an enormous extent the resources of construction.

Characteristics of the Old Forms of Metal to which the Name Steel has been universally accorded.

But what has been here said of the definition of steel, for the reasons we have stated—that is, in regard to the relation which mechanics have to the new metals for which, as we have seen, many claim the title of steel—has had no specially direct reference to that form of iron or alloy of iron which, previous to the introduction of the new metals, was alone known by the designation of steel. The only reference to this, the old-fashioned steel, which has as yet been made, is that it is a metal which is capable of being hardened and tempered, and when so treated is capable of taking a fine cutting edge. But it will be perceived that this definition, if so it can be called in a truly scientific sense, refers only to the capabilities of the metal at one time known, and only known, as steel. It tells us what can be done with it, how it behaves, so to say, with certain treatment; but it does not define what steel is considered as a combined body, or whether indeed it is a combined body. It is like the position we are in on being told that there is a certain amount or sum of money, but not told—what in point of fact, for one reason or another, we wish to know—of what or how it is made up. Now, this precise definition of what steel really is, is one which carries with it much of great practical importance, involved in the manufacture of iron or steel, or of both; for both are concerned, as we shall presently see, in the making of steel in the ordinary way.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER V.

WE stated at the end of last paragraph in preceding chapter that it is with the "manifestations" of that "something" to which the name of "force" is given that the mechanic has to do. If he has a "grinding stone" to turn, in putting an edge on his axe or his chisel, and only his own strong arm to turn the grindstone with, in the sharpened axe or chisel he has obtained he has got the work *done* which he wished to do. And, however much he might gratify his intellectual pride by *saying* that he had discovered what that force was, or that he had clearly traced it to its origin, his common sense would tell him that even of what he said he knew did exist, its existence and the knowledge of what it was would not help him one whit in turning his grindstone and sharpening therewith his axe or his chisel. And, if he heard a brother mechanic, who had been turning a lathe mandrel by the force of his foot and leg, say that he had discovered what that force was, and could trace it to its origin, but on comparing notes found that his brother mechanic's discovery (so called) was the very opposite of his own—we may conclude that his common sense would also in such a case tell him that it would be in every way the most practical thing to do to let all those abstruse searches after knowing what we may from past experience shrewdly suspect will never be known, alone, and confine himself to his *applications* of this force, whatever it is or may be, in the doing of his daily work.

The Manifestations of, and the Applications of Force to his Practical Work, the Chief Concern of the Mechanic.

This, to take an analogous case, is what the electric telegraph engineer does. He knows nothing—absolutely nothing—of what electricity is; it apparently is present in every substance, but how it is so and how it is created—in brief, what *it is*—he knows, as we have said, nothing. But this does not trouble him; he takes it as it is, knows how to excite or bring it out of bodies, and makes it do all the varied and marvellous work of which we all know. The most elaborately detailed and the most abstruse theories trying to show and prove what electricity *is* would not, however closely he studied them, help him one whit in his practical work. No more would the photographer be helped in his practical work, who deals with light—as to what *it is* no two scientific men are agreed—who bothered his brain with all manner of theories concerning it. And if those theories as to what electricity is were contradictory, his mind would probably be so perplexed, if an inexperienced electrical practician, that he would be the worse, and none the better, for the study. And this applies, as we have endeavoured to show, to all abstruse and, as a rule, purely metaphysical theories, opinions, or "conjectures" concerning *force*. The last term here used, "conjectures," is possibly the best to designate those positively useless inquiries into a region of which we are never likely to know anything. And the inductive philosopher never deals with conjectures as if they were facts; and it is to "inductive philosophy" or science, with its facts, and its facts alone, that we owe all those brilliant and practical discoveries which have given us such material help in every branch of industrial work. True, the inductive scientist or philosopher must deal with conjectures—for it is a conjecture of his imagining that such or such a thing may exist which leads him to try to find out whether this does exist or not. Here, as in numerous other cases, light is thrown upon the word we have here used by looking at its root or derivation. "Conjecture," then, we find to be derived from two Latin words—*con*, with, and *jacere*, to throw; so that a conjecture is literally "throwing together" a number of things. The word "surmise" is often used as synonymous with this term conjecture, and is derived directly from the old French verb *surmitter*, to suggest, and this from *sur*, upon, and *mettre*, to place; so that a surmise as to what force is, for example, is the placing of things or thoughts one upon another, as conjecture is the throwing of them together to form a single thought or subject. But here let the reader carefully note *this* distinction or point, for it lies at the root of all our progress in mechanical work. While with the inductive philosopher conjecture is allowed to go no farther than the point above named, he deals only with facts, and if he cannot get facts to support his first conjecture he never thinks of putting *it* forward as a thing to be believed simply because he says it is, or is induced to believe it himself. Facts, and facts only, are to be dealt with in his work. Some particular course of investigation may be taken up by him as originating in a "conjecture" that certain things in connection with it exist or are likely to exist. But he must never assert—and the true man of science or inductive philosopher never does assert—that these do exist till he has proved their existence. The very term "inductive," derived from the Latin word *inducere*, to lead into (*in-* and *duco*, I lead), indicates that we must go completely *into* a subject or course of investigation before decided opinions concerning it are given forth, or dogmatic assertions made about it. And going into a subject, not beating about it outside, is the only way to get at the *facts* of what it is. A sailor, however nearly he approached, could certainly not be said to have practically arrived *at* the harbour—his point of destination—till he had got *into* it. The owners of his vessel would have to wait long enough for the goods it carried if he kept "beating on and off" *outside* of it. These considerations are of the utmost importance to the young mechanic desirous, as the saying is, of "bettering himself" in his profession; and they have the closest bearing upon the matter now under consideration in relation to certain definitions in the science of mechanics. The sooner, therefore, the youthful student gets hold of this the better: namely, that force, like this motion which it produces, is a something—if not actually tangible, is practically something—an "entity," a thing in existence which he can, paradoxical as the expression is, lay hold of and bend to the purposes of the work he has to do. The word "entity" here given is much used in scientific disquisitions. It is derived from the Latin *ens*, *entis*, a "being," a thing which has an existence or a being.

Further Practical Considerations connected with Force and its Definitions.

Leaving this, the region of perplexing and unsatisfactory theories, and entering that of *fact*, he will be on safe ground, in which he will find enough to help him in his daily work. If he strike his hand against a wall, or in chipping misses the chisel and peels the skin or flesh from off his thumb with the hammer face, he has painful evidence enough of what "force" can do; just as a mate with whom he is at "outs" would have, if he knocked him down; and he has no doubts at all about "force" being a thing which he can use, or, as in the latter case, abuse, nor is at all troubled by fine-spun theories, which would make it out to be some abstraction of the brain—some "airy nothing." But while in the cases above named, and in an infinite variety of ways coming up perpetually in every-day life, seeing that force exists as a something, or what may be called here a practical power, capable of being exercised or brought to bear by himself personally upon objects external to himself, he will have no difficulty in perceiving this other fact, —that "force" as a practical *entity*, a thing which exists, and which, by the effects it produces or the work it does, can be estimated or measured, is chiefly, in the practical purposes of mechanical work of all kinds, obtained from, so to say, or exercised by things or objects other than ourselves. What the sources of force, or, to use the common expression, power, are, we shall have special occasion to note hereafter. Force or power, like electricity, may be supposed to be latent in certain things or objects—lying waiting, so to say, to be called forth for some useful purpose; and just as electricity is excited to manifest itself, so may certain objects or things be excited to give forth their force to act upon other objects or things external to them. How this is done we shall have occasion hereafter to point out. But like electricity, which, although we know that it is present in bodies in an insubstantial, or, as we say, latent form, so in the case of force we can only become aware of its existence by its effect, or what it does. Now, of those effects of force, the one which is most apparent, because it is the one which is most frequently displayed, is that of "motion." And it will be perceived—if the student will refer to the definitions of "force" in a preceding paragraph—that this effect is the one named as produced by the cause of force, whatever *per se* it is. So universal, or, rather we should say, so general, is this manifestation of what force effects in the way of producing motion—and so generally also, in consequence thereof, is this relation entertained—that some maintain that force can only be actually and practically known to us by the movement of bodies, or it can to us only exist when it produces motion. In other words, they say that there is no force when there is no motion.

Some Considerations connected with the last-named Definition of Force—Pressure.

How greatly this last-named view—which is, however, held by many, and some eminent, authorities —complicates what, when viewed in the prudent, common-sense way noticed in a preceding paragraph, is a comparatively simple matter, needs scarcely to be said. The plan of our papers precludes our entering upon an explanation of this, for it would possess little practical value to the reader; but it is indeed only necessary to state that it is not true that force can only be manifested or made known to us when motion is produced. The statement of some just noticed, that there can be no force existent unless motion be produced, is wrong, for it takes no account of "pressure," which is just as much an effect of force as motion; and it is just because its manifestation is so seldom witnessed with the frequent, the almost continuous manifestation of it, in the way of motion, that it is so little thought of. And a very important lesson may be learnt by the reader of the value of looking at all sides of a subject, from the fact that there are those who maintain theories which can only be correct if facts of daily existence do not exist—paradoxically so to put it. Now, pressure is a fact, as well as motion: a fact which can any day be painfully proved. A finger happens to be placed in the space between the door-cheek and the edge of the door-style, and some one closes the door; that in so closing it some one is exercising force, or causing it to be manifested, his common sense tells him, and tells him that its effects are felt, and sorely too, upon his finger, upon which there is pressure enough—more than he cares for—but in which there is no motion. He only, in such a case, wishes there were, so that he could move it out of its painful position; or had been, so that he could have moved it, and in time to prevent the pressure. No doubt it may be said that, in the case of goods pressed under the powerful influence of an hydraulic press, there is motion in the movement of the particles or atoms of the body or substance of the goods pressed. It may also be said that "compression" cannot exist without movement—the term, derived from the Latin words *con*, with, and *pressere*, to press, including a bringing together of the constituent parts of the body within narrower limits—that is, each one being brought or taken nearer to its neighbour. But there is no motion in the goods as a whole, considered as a parcel or package or a single mass or body, any more than there is movement in the finger which has been caught between the style and cheek of a door afterwards closed, though there has been a movement or a squeezing together of the fibres of the flesh. The victim would, as we have said, have been only too glad had there been motion, in the sense that the *finger* had been moved out of the way before the pressure was put on, or the "force" applied which produced the pressure. Pressure and force, although frequently used as such, the student will perceive are not synonymous terms, strictly speaking, for pressure is a product of force just as motion is—and motion, or the amount of it, is not, as some say, force itself, any more than pressure is.

Another Term frequently applied in connection with Force. —Energy.

There is another term, or word, very frequently met with in mechanical works and dissertations—namely, "energy," which is frequently considered to be synonymous with "force." The terms, no doubt, are closely connected, but are far from meaning the same thing. Take, for example, the force which exists or dwells in the human body, or which that body is capable of exerting. We know that this is capable of being exerted within the limits of a wide range—from the force exerted in wiping away a tear or brushing aside a fly, to lifting a drowning neighbour from a stream. We would counsel the young reader, *at this stage* of his progress, not to enter into any speculation of his own, or to read much of the speculations of others, as to *what* this force is, or how it exists in his body. He will thus be spared the trouble of leading himself into the holding of some strange metaphysical and bewildering notions. Let him, on the contrary, at least for the present, take the common-sense view of the matter, and be content, as well he may be, with the *fact*—which is a fact, metaphysical writers to the contrary notwithstanding—that this force does exist, and that he is capable of using it as a distinct entity, or a something, exactly as he uses anything material which he possesses, such as money, of which he may spend much or little, just as his mind or will determines. And common sense tells him that this view is correct, and practically the only one worth a rush to him in his daily life. And further, that, as in the case of money here supposed, he can expend, give out, or manifest as little of the force his body possesses as he chooses, or as much of it, and if necessary to its full range. And where this human force is so put out, or developed, we sometimes use a term by which to designate it, and this we call "energy." When this term is employed, what is meant by it is well known to the majority of us, it being only to the thoroughly uneducated that its meaning is obscure, although often not even to them. When we say that a man is devoting all his energy to any piece of mechanical work or bodily labour, we know, and in other words say, he is putting all his force to it. A man in cleaving wood with an axe may dreamily and languidly go through the work, and may take many strokes to cleave a single piece; and when we say that he is "inergetic" we use a term the meaning of which is well known to us, and which is, in fact, only saying in another way that he is not putting out his full force. But if, on the contrary, we see that with one vigorous stroke he cleaves the wood, we say that he is energetic, which simply means the converse, or opposite of the above; and we know at once that he is energetic—some would say *forcible*.

In common and familiar language, when we see a man thus energetic, if we cannot say that he is working vigorously, and apparently doing his "work" well, we know at least that he is trying to do it to the best of his ability. The meaning of the term "energy," which it is essential that the youthful student of mechanics should understand, may be made clearer if we look at the derivation of the word; and a very curious point is raised by this, which is by no means generally or widely known. The word is derived from the Greek word *energos*, and this again from two words, *en* and *ergon*. This last word, *ergon*, means, in the Greek language, "work." And here comes the suggestive point. This word *ergon* is itself derived from, or has its root in, the word *ar*, which means to "plough"—which operation was deemed, in the early days, to be synonymous with the phrase "to work," as if ploughing were then the one essential work which had perforce to be done, if work of any other kind was to be kept up. For man had then, as he has now, to eat in order to work. Now, ploughing, especially in first turning over lands which had been left in their natural condition—and this change would increase as civilisation increased—is work in the doing of which "force" is required, and which, however obtained, is always essential.

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER II.

AT the end of the preceding chapter we began a paragraph on the value of the indicator in ascertaining the true character of the working of a steam engine, stating that not a few are to be met with who know but little concerning it, and that little not always accurate. For such as those, and for readers who come for the first time to study this invaluable adjunct to the work of the steam engine user, the following remarks in a series of paragraphs are presented to their notice. They will embody not merely a general description of the ordinary, or what may be called the initial or elementary form of the apparatus, but of some of the many improved varieties which are more or less largely used. The principle of its operation will be glanced at, the method of applying and using it described, and the "indications" or "diagrams" which it gives explained. The modes in use of calculating or ascertaining the value of the "diagram" will also be described, and practical notes as to reading off the hints which they give as to the character of the work which was being done and the power given off by the engine at the time when the diagrams were taken. The steam engine indicator is not of recent invention. It is as old as the modern steam engine itself, for Watt applied it to his great invention. Though as old, then, as the steam engine, its use was however for long almost unknown to the users of steam engines, except in rare instances. During the past thirty years it has gradually gained admission, as one of the necessary helps and appliances, among those connected with steam engines. Therefore there is no intention to claim, for any one class or in any one district, originality in respect to its daily or frequent use, in the paragraphs following. It is admitted, by those who possess a general knowledge of its workings, to be indispensable to all who employ steam power. Though known to every engineer who has had opportunities of attending to steam engines, yet still it will be found that a large number are yet in comparative ignorance of its usefulness. This ignorance still exists in the minds of many—perhaps mainly from the necessity of having plain instructions given them as to its use and the simplicity of calculating its diagrams or indications. A correct idea of the value of the steam engine indicator by the user of a steam engine would at once cause him to place a high value upon it, as a valuable index to him as to what power he was actually receiving from the combustion or consumption of a certain weight of fuel. The working of a steam engine as to its interior may be compared to that of the interior of the human frame. Its power-giving parts are hidden from the eye, and thus the true working of these, their real facts, are concealed. The medical man, in order to ascertain certain conditions of his patient's health, makes use of an instrument to test what is the condition of the breathing functions before he ventures to prescribe for any malady or illness connected with them. The patient can often give such an account of the position of his aches and pains that the physician can draw, from his great experience, a moderately correct conclusion as to what is the cause; and once knowing the cause, attempt to remove it. But in other cases he cannot, knowing only in a general way that he is unwell, or, as the popular phrase is, "out of sorts." Without some means of ascertaining internal actions which indicate the symptoms of the complaint, the physician would be generally at a loss to know how to prescribe. But by using the "stethoscope" in the particular class of complaints alluded to, he can tell, through long experience in listening to the sounds which the organs give out in the breathing of the patient, which are conveyed to his trained ear by the instrument, with marvellous accuracy what is the condition of those organs. For a healthy sound has its own peculiarities, just as has a diseased one. And what the stethoscope is to the surgeon, so the "indicator" is to the engineer in enabling him to ascertain the internal working of the steam engine employed as a prime mover to give out power. In the case of the steam engine the only information it can give is that of irregular motion, or that of a larger consumption of fuel when it is out of order than is necessary to be consumed. Many engine users, and "tenters" as they are called, have been dismissed from their work through ignorance of the state of the working parts (those which cannot be seen). Had the attendant employed a steam engine indicator, and had the knowledge which is required in its use, he could not only have given satisfaction to himself, knowing that certain results proceeded from certain causes, but having experience so as to direct him to that which was the immediate cause, he would have saved himself a world of anxiety and trouble, and in addition to that his employer would have had the more interest in keeping him in his position. Employers are not always blind to their own interests: they know when they are possessed of a faithful servant, and that to exchange servants holding a responsible post is by no means desirable, and is rarely done, except in case of some unusual conduct or of a faulty character.

The purport of this part of the present series of papers is not to give the reader details of steam engine construction, or of the modes of using and repairing it when not in good order. All this will be taken up in succeeding parts. What we have now to give is in connection with the indicator only.

The indicator, as we have before said, is not of recent date, though its general use is but of recent application. Thirty years ago not more than one out of ten of those who had the care of steam engines had seen an indicator, much less did they know anything of its value. But it is now in the hands of a large proportion of foremen or engine tenters, some having but a very imperfect knowledge of it when they have manipulated it, though others, but few, realise the value of, and are able to profit by, the diagram which it produces. The steam engine indicator, like all other instruments, still retains the principle, but its form is as different to-day to what it was in the days of Watt as that of any other old machine or instrument. The change may be said to lie partly in form, and partly in the different construction of the mechanical arrangements. It is now more portable, and also much more correct in its operation. Perhaps the most accurate steam-engine indicator of to-day is that known as "Richards'"; its working parts, of course, being similar to all those which have preceded it. Ordinary education now being within the reach of all, in consequence of the present system of schools, should a diagram be produced from the steam engine, a boy who has passed the fifth standard could, with a few examples, learn quickly to "read" the diagram, and calculate the power the engine was producing; and the knowledge of figures, the simple rules of arithmetic, are now within the range of the generality, at least, of young men.

A Capability to understand the "Points" of Steam Engine Diagrams necessary in addition to that of computing the Power of the Engines from which Diagrams are taken —Points in the Practical Management or Use of Steam Engines involved in this.

But a knowledge of figures is not the only matter necessarily requisite in the indication of a steam engine. That is but the preliminary. The next and the great value of indicating will be fully shown as we proceed in giving diagrams of different forms, and explaining the results and causes of the different style of diagrams, with remarks on each, so that the readers, more particularly those who are somewhat conversant with a steam engine and the parts which produce either good or bad results, can readily understand how to improve them or rectify certain errors. Thus an instrument which can be applied to the steam engine, and which gives to the user of it the real state and condition of those parts which cannot be seen with the eye, which can only be guessed at without, and can only be ascertained absolutely, with definite precision, by the aid of the "indicator," can scarcely be overvalued. The "diagrams," when taken by its means, will appear to those ignorant of it a mystery, and likely to carry no more profit by them than one who is totally unacquainted with the system of stenography receives from a piece of shorthand writing.

The following paragraphs are intended to give the necessary information on the use of the indicator, also of the diagrams when taken, and how to make the necessary calculations from them. They give also full instructions how to detect faults, if any—*i.e.* so far as economy in consumption of fuel, and how to gain steady working are concerned, so that they will thus be all the more practically useful to our readers. It is only right to state that, having had many years of experience in its working, we have ever found it to be a correct discoverer, and in its diagram describer, so to say, of the true state of affairs in the invisible or dark room of the "cylinder," and thus telling us the exact condition of it, thus fully disclosing the hidden or secret workings which may thus be said to be made visible to the eye of him who can read the diagrams properly which the indicator gives him. When the lines are so spread upon paper, they are then open for inspection, and to the learned they are so far understood that they can be treated as the case requires. We say as the case requires, because circumstances vary, and therefore such arrangements must be made that, whatever the circumstances may be, it can be accomplished if it be within the possibility and the capability of the power of the mechanism of the steam engine. This can be done, not by the rule of thumb, but on principle. The diagram on the paper shows, in the first place, the position of the engine as to the power it is exerting, and secondly as to the amount it is capable of performing in addition to the power it is already exercising. This being the case, it arms the steam engine user with a power so that he can at once set to work to provide for the requisite steam power that is required. If no extra power be required, the diagram points out unmistakably to those in charge, whether there is any necessity for a change to be made in the arrangement of working the parts so as to give the best result.

A Point to be considered in Working the Engine in relation to the Diagram taken by the Indicator.—The "Setting" of the Valves of the Steam Engine.

Two results are required to be gained by arranging the working parts, and which can only be done on principle, after having a figure (the diagram is often called a figure) taken without working in the dark: *i.e.*, firstly, to so regulate the valves (which are the real working parts by which the changes can be secured) that the steam engine can be regulated to work smoothly, This is very important—*i.e.* regular turning and smooth "running." To arrange the valves so as to gain the above result has an economical effect of high value: it also prevents breakdowns and sundry repairs, which often take place where valves are incorrectly set. The word "set" is mostly applied to the regulation of steam valves. In short, the difference of the wear-and-tear in the various working parts between an engine which has the advantage of being carefully regulated and the one which is neglected and is working irregularly and "shaking," as the phrase is, is simply the difference between repairs seldom and those frequently required, together with the chance of a total breakdown. Secondly, economy in working steam engines is also a desideratum with manufacturers or users of steam power to a large extent. Coals being an article of everyday consumption, and also an expensive item, it is all the more necessary that the best means should be adopted to curtail such costly expenditure. The use of the "indicator" and a knowledge of it prepares the person in charge of the engine to so far adjust the valves that the object required can be accomplished. It may in other words be called a "detective," an "informer." What can be more valuable than a machine which can discover faults, and that with little trouble, and when discovered can show where the fault lies? It is no false informer: it may be relied upon; and hence the value of such a piece of mechanism. Our experience with steam engine indicators for a period of more than thirty years has been very wide and extensive, so that we have every confidence in recommending such a valuable adjunct to the engine-room as an indispensable auxiliary to it. Economy in working steam power is at this day regarded as one of the first steps in a well managed concern. Manufactories of every kind have to depend largely on the principle of economising in every branch which entails cost; and therefore the mighty consumer of coal, the steam engine, must have its share of attention. An old proverb, which may be repeated, is valuable when put in practice—"Take care of the pence, and pounds will care for themselves," but in the use of coal with a well arranged engine its application saves its pounds. The difference between a steam engine being properly set to work for saving coal, and one which is improperly arranged, might be at a cost in the consumption of coal equal to 25 or even 30 per cent., hence the importance of a knowledge not only of the steam engine as a machine, but of the application of the indicator. We cannot possibly praise the indicator and its use more than it deserves, and those who have had experience with it will admit all and more than all we have said in its favour.

Practical Points connected with the Use of the Steam Engine Indicator.

The "indication" of the steam engine is obtained when the engine is in full operation—*i.e.*, first, when it is running at the regular speed at which it is required for the machinery which has to be driven; next it must be ascertained that all the machinery which depends upon the engine for motion is in full work; this being done, the work of taking the indicator diagrams can be proceeded with, and this diagram will be traced upon the paper which is attached to the cylinder of the indicator, and when it is worked out (as will be shown how, as we advance in this paper) the actual power which is exerted at the time the diagram is taken, will thereupon be presented. The result which is exhibited must not be understood as being the net power of the machinery which has to be turned, but the total power which is required to overcome the friction of the machinery which is in operation. We shall, as we proceed, refer more particularly to the mode of ascertaining the total power which the steam which enters the cylinder of the steam engine produces, secondly to the power which is required to overcome the friction of the engine and shafting, and thirdly and finally to that which is required for the machinery alone. Such a mode of procedure fortifies the engineer or owner of the works against adding more machinery to that which is already at work than the condition of the steam engine is capable of performing. Therefore the use of so valuable an appliance as the indicator is of the utmost importance to those so engaged with machinery requiring power. We may further add that the steam engine indicator informs the engineer or engine builder how to determine the strength of the metal in those parts most likely to be affected—*i.e.*, those parts of the engine which receive the greatest amount of strain, and which should be so judiciously regulated as to provide for little irregularities in the way of checks or other changes, which all engines are subjected [illegible] from the action of the machinery they turn, which may have been stopped, and suddenly put to work again. Extra friction arising from change of weather, from dry to that of damp, may also be ascertained [illegible] means of the indicator. Belts become tighter and cause more friction in damp, than in dry weather. Extra friction is more especially caused in works where a large number of cords, ropes, or finer kinds of cord, or what is commonly called "bands" are used; where such abound the work to be done is considerably augmented. Every kind of change in the directions we have named above requires to be so provided for that it will comparatively compensate for such emergencies.

The indicator is truly named: it is an "informer," a "forewarner." It is the red light—to borrow a phrase from railway working—to those who understand signs. When a diagram is taken and it appears larger than the previous one, it points out again the necessity for inquiry in order that the cause may be ascertained. In case of extra speed being given to machinery which is in operation, it also gives information of what has been done—*i.e.*, it shows the power required to be obtained from the steam engine, and which consequently requires a greater consumption of coal. We have found the use of the indicator, where power is "let off" to tenants, to be of the greatest value. It often happens—and we suppose that such is a general weakness in man—that he requires for every penny spent a pennyworth of something for it; and it often does fall out that one having steam power is actually getting more than is due to him, and this may be largely added to by his increasing the speed of the machinery, and thus he may be obtaining a penny-farthing's worth of power for his penny. This kind of apparent does not always arise from actual selfishness, but sometimes from a want of proper knowledge; and if conversant with the use of the indicator, he could no longer profess (at least) to be ignorant of the result, that more speed in the machinery will require more power, and the additional power must come from the engine, and thus a greater consumption of coal is going on, therefore the power provider is at so much of a loss. We have adduced the above circumstances, possibilities, and the like, that we know such as deal—for in reality "letting off" of power is a distinct trade—in letting off power are subject to. Besides what we have named as being a loss to those who find power for tenants, they are also subject to the loss arising from being overloaded by the tenants' work—*i.e.*, having more power to furnish than can be furnished with safety by their steam engine. Here again the detective instrument may be set to work, giving information to the principal or owner of the engine as to what has taken place; and therefore he puts some one to work to ascertain the real cause, in order that it can be remedied or compensated for. The value of such an instrument will, we think, be so far appreciated, that all who desire to act on sound principles and on safe ground, as well as to work on an economical plan, will therefore, if wise, so esteem the indicator as an indispensable instrument that they will be provided with one; for the reasons above alluded to are of the utmost business importance.

Though the "indicator" is expensive at first cost, it nevertheless contributes to economy. With care it is seldom out of order, and therefore very little expense follows upon even its continued use. As we progress in our remarks upon the diagrams as we draw them, we shall have to point out other important points which are necessary to be read and valued as leading to economy, etc., etc.

General or Popular Description of the Indicator.

This is a small cylinder, *a a*, provided with a piston, to the under side of which the steam from the main part of the engine cylinder at its upper end is admitted by a pipe regulated by a cock, *b*, fig. 1. The piston-rod is supplied with a strong spiral spring (partly shown through the slot *c c* in the upper part or cylinder *d d*), the office of which is to press the piston of the indicator downwards after the steam which has pressed it upwards passes away, as it is exhausted from the cylinder of the engine. To the spring a pencil rod, *e*, is attached, the point of which at *f* works against a small sheet of paper. This sheet of paper is passed round a vertical cylinder, *g g*, running on a centre attached to the frame, *h h*, of the indicator. The cylinder has a motion given to it on its centre by a small pulley, *i i*, round which a cord *j* is passed, this being connected at its upper end towards *k* with the parallel-motion radius bar of a beam engine or to the cross-head of the piston-rod of a high-pressure engine which reciprocates to and fro; the end, when pulled out by the outward motion of the rod, as in the direction of the arrow *l*, causes the cylinder to move round a part of its revolution, as shown by the curved arrow *n*; and on the piston-rod of the engine moving inwards, a spring within the cylinder *i i* makes it return in the opposite direction to *n*, coiling up the cord *k j* in direction of arrow *m* as fast as it is released by the backward motion of the piston-rod of the engine. The indicator being thus arranged, its cylinder, *a a*, in communication with the inside of the engine cylinder, and its spring box *i* and "drum" or cylinder *g g* with the moving part of the engine, the cylinder piston, in *a a*, of the indicator is kept moving up and down, and the spring box, moving also the pencil-rod and pencil *f*, moves from right to left on its centre alternately.

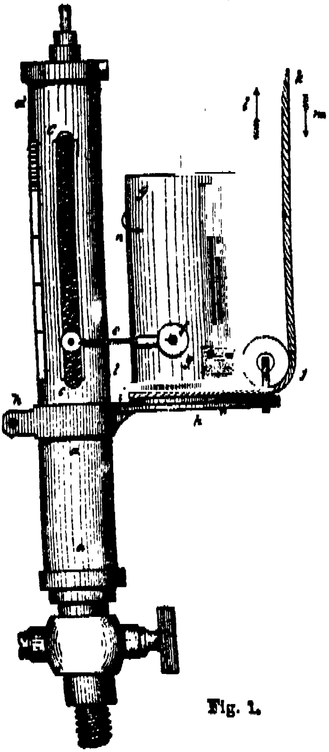


Fig. 1.

THE BRICKLAYER OR BRICKSETTER.

THE PRINCIPLES AND PRACTICAL DETAILS OF HIS WORK.

CHAPTER III.

The Dimensions or Size of Bricks used in Ordinary Building Work.—The "Standard" Size of Brick.

BEFORE proceeding to this part of our subject, we may as well state, with regard to paving bricks, alluded to at the end of last chapter, that they are made of a good quality of soil, and are burned very hard, to give a walking-on or working surface capable of resisting the wear and tear to which they are subjected. Probably the best paving bricks are those made in Staffordshire, the colour of which is generally some tone of blue.

The "standard," or what may be called the "building dimensions" or size of bricks, are—length nine inches, breadth four and a half inches, thickness or depth three inches. The relation to each other of those determinate and always invariable dimensions enables the bricklayer to get in his structures what is technically known as "bond." How this is obtained in brickwork will be explained in future paragraphs. At one period in our history, and that for a long time, bricks were excisable, paying a very heavy duty per thousand to Government. In order to enable the duty to be levied with ease, a determinate size or bulk of brick only could be made; and this bulk was regulated by the dimensions that we have named above. It so happened, therefore, that no bricks could be legally made of dimensions or of form other than the solid parallelopipedon of nine inches long, four and a half broad, and three inches thick. Although it was known that other forms or sections of bricks gave great economy and high value in construction, brickmakers were entirely precluded from any attempts to introduce such improved constructive forms as had been or clearly could be designed. So obstructive to all advance in improved brick construction was the excise law, that a strong agitation in favour of its repeal was at last begun. This was carried on in face of the difficulties which usually environ such agitations with varying features; but at last the influence brought to bear upon the subject was such that the duty was wholly taken off, and the designing and making of brickwork left entirely untrammelled by any external influence. This was some thirty years ago, or thereabouts, and since that period bricks of all sizes and forms have been introduced. It is only right, however, to state that the full freedom possessed by the trade has not been taken advantage of to anything like the extent or in anything like the number of directions which could have been taken. Several exceedingly valuable forms in a constructive point of view have been from time to time introduced, but those have not been availed of to any great extent in practice, while some have been allowed to die out, and are now practically and absolutely unknown. Architects and builders, with advanced and enlightened views as to what brickwork construction might be made, have, in fact, found that it is much easier to get a law repealed than it is to get rid of trade prejudices and trade opposition. For not seldom has it happened that the "trade"—those engaged actually in the work of bricksetting—have passed stringent laws and most distinctive regulations, which practically forbade the men to do work in which improved and in some instances most valuable forms of bricks and modes of construction were used. In this connection a parallel case may with some practical utility, as being most closely connected with the question of technical work and education in this country, be here cited, taken from another branch of building. The use of wrought-iron beams in fireproof and other kinds of buildings was first introduced on the Continent, markedly and perhaps most successfully in Belgium. So valuable were these found by architects to be, that it gave rise to a highly lucrative branch of work in the iron works of the Continent, especially in those of Belgium. Our iron works, with their superior facilities, might have had this trade; but apart from the prejudices of the masters at the first—which must not be overlooked as an element in the matter—when those prejudices disappeared, which they soon did, and they were ready to make the beams for our own architects and builders, they found for a time all progress stopped, simply because the trade, that is, the actual workers, forbade the men to make the sections required. The result practically was that the Belgian iron workers had the monopoly of the trade, and this they have maintained at a point not very far from its original completeness to this day. It is difficult to estimate the actual money loss which this country must have sustained by our practically throwing work into the hands of our rivals and opponents in trade. Facts such as these—for they are not the outcome of opinions merely—could be cited in connection with other branches of our national trade, and have given rise to national losses of the gravest character, which have influenced not only the past, but are likely still to influence the future career of our technical trades.

Brick as a Building Material, compared with Stone—Estimation in which each is held Largely Dependent upon Circumstances of Locality, the Abundance or the Reverse of the Materials.—Stone almost universally used in certain districts of England, and throughout Scotland.

In connection with the value of brick as a building material certain points and considerations are worthy of notice here. And in this connection it is somewhat suggestive, as it is curious, to note that the estimation in which brick or stone is held in any given locality, or the relative value assigned to each, is dependent in large measure upon the simple fact of their relative abundance. Thus, if a district is so well supplied with stone, and this of good or even only of fair quality, stone is used as a rule as the building material, and brick, if used at all, is used only exceptionally, and often for subordinate purposes, in connection with stone—such as in the building of interior or partition walls; and if used alone, only as a rule for work of no great importance. Now, in districts so situated, it will usually be found that, not content merely with the use of stone with which it happens to be abundantly supplied, many of those who so use it seem to think it incumbent upon them to decry brick as a building material, refusing—as from experience the writer of the present lines knows they so often refuse—to consider the relative merits of the two materials upon a sound practical if not on a scientific basis. The converse of this position of matters may be supposed to exist with equal force. Still some practical experience of districts where brick is used on a much more extensive scale than stone—in fact, its use being the rule, that of stone being the exception—compels us to say that, taking matters on the average, we have not found that those who use brick habitually think little or nothing of stone or greatly decry its use as a building material. There is, for example, no case, at least within our knowledge, in England parallel to that met with in Scotland. In the latter country stone may be said practically to be the only building material used, at once for public and for private structures. And it is difficult for one who has not come in contact with the circumstances connected with daily working life there, and contrasted it with the like circumstances met with in the districts of England with which they are acquainted, to conceive of the low estimate universally taken of brick as a building material. Not merely the dwellers in the houses, but the majority of those who build them, can apparently conceive of no circumstances in which brick could give a dwelling-house, for example, so comfortable to live in and so lasting as one built of stone. One hears on all sides opinions given with the greatest gravity that houses built of brick may do for the warm climate of England, but that for Scotland, with its weeping climate and its colder air, stone is the only material which will give a warm house and materials impervious to damp. It is forgotten or overlooked that not only are winters, if not normally, exceptionally, and very often, quite as severe in England as in Scotland; while for a weeping and a damp climate we are not aware that any part of our island home is quite free from it, while some districts in England will bear away the palm for rainfall. Still more curious is it, that in Scotland in this connection it is quite overlooked that comfortable, warm and dry houses are, if not as much esteemed, as greatly necessary in England as in Scotland. And we have always been under the impression that a fault found with their English brethren by Scotchmen is that in England material comforts are too much thought of.

Brief Inquiry into the Claims of Brick to be considered an Eminently Sound and Economical Building Material, Superior in many ways to the Ordinary Qualities of Stone.—Decay of Stone.

Apart, however, from local prejudices—which have in daily life a remarkably powerful influence in deciding the most practical of points connected with it—it is from a scientific point of view well worthy of inquiry whether brick is a poorer, and as some say a much poorer, building material than stone. While some materials or substances are practically imperishable (and they are very limited in number), the vast majority of those with which man has to deal, and with which he carries on his daily work, are liable to decay. This indeed may be said to be characteristic of all substances; and although there are exceptions, we do not absolutely know that they really are exceptions, for the element of time is to us only relative, and we cannot tell the limit within which those apparent exceptions to a general rule would cease to be so. Practically, therefore, decay in material substances is the rule; and stone, although we so popularly associate with it ideas of a lasting durability that if we raise a memento of any event in stone we deem it certain that it will be handed down to all time. But while thus popularly thought of, stone practically is a material liable in many instances to a quick decay. This characteristic is, of course, relative, and varies in different kinds and qualities of stone—granite being, for example, a much more lasting stone than sandstone or some qualities of limestone. Much depends upon the influences to which stone is subjected, and of those the atmospheric influences are the most powerful in their deleterious action. In damp climates, and in districts where the air is largely contaminated with smoke and the fumes of furnaces used in certain manufactures, stone of all kinds is liable to decay, and in the majority of instances this is rapid and complete.

Decay of Bricks.—Superiority claimed for Brick in this respect compared with Stone.

Brick—and here we assume that it is at least moderately well made, of a good average quality, just as we assume, in comparative observations between it and stones, that the stones used are of average if not of the best quality—brick is also liable to decay. But if the results of observation of ancient work be worth anything, then this may be fairly challenged for brick, that is less liable to decay than stone.

THE COTTAGE AND THE VILLA GARDENER.

THE LEADING PRINCIPLES AND PRACTICE OF THE ART OF FAMILY GARDENING.

CHAPTER II.

Points to be attended to in organizing a System for, and in laying out, the Cottage Garden, to meet Contingencies of Seasons, Diseases of Crops, etc.

IN laying out his garden the labourer or cottage gardener should aim at growing as great a variety of crops as possible. It is a great mistake to confine the produce to one or, at the most, two kinds of crops, such as the two popular or normal crops of ordinary gardens—potatoes and cabbages. This is not a system calculated to make the most of the garden ground. A variety of crops brings with it more advantages than one. In the first place it is a prudent system which has several crops under cultivation. The seasons vary very much with us, as we have all but too good—or too bad or powerful—reasons to know. But varying as they do, and thus being bad one year for a certain crop, they may be good for it in the year following. Thus it is that one season, bad in its effects upon one crop, will be beneficial for another; and thus if the garden is growing several crops it will be strange indeed if all of them are failures. Some will be very good, others will be moderately good, while those which are decidedly bad may be few in number, or but one or two at the most. Again, there are causes of crop failure other than the seasons, such as diseases, insect pests, and the like, which act as prejudicially as an untoward season. It is possible, indeed, that these diseases—even perhaps the ravages of the insects—may be caused by, or at least greatly influenced by the seasons, and this in the latter case we believe to be the case. But looking at diseases and insect pests as separate and distinct scourges, quite apart from the scourge of an untoward season, it will be found, in the practice which gives a variety of crops to the garden, that while an insect pest, for example, which comes one season destroys one set of plants utterly or nearly so, another crop or crops will be spared; while others may be only partially attacked, and a minimum of loss be the result.

Economical Advantages of Variety in the Vegetable Cropping of a Cottage Garden.

But altogether apart from the economical aspect of the system of variety in cropping, which may avert the total loss of all crops if one or two only be cultivated, there is still another advantage to be obtained by having more than one or two crops, and that the same year after year. And this advantage is very great in a health or physical view of the question. For all physiologists and physicians agree in this: that variety in food is, or what are called "changes in food" are, beneficial to the system. Further, we are all so constituted that each individual has his own likes and dislikes. And some members of the cottager's family may be greatly gratified, and indeed be much the better physically, by having now and then a vegetable he or she may like vastly better than the usual or ordinary vegetables grown in all gardens. And as the happiness, at least the comfort of life, is made up of little things, why should this little thing be withheld? A good and wise and kind father will, in witnessing the gratification of his wife or children at having this little thing accorded, be gratified himself. And it is a question whether this be a "little thing," after all. We are inclined to decide that it is anything but that, and the principles of physiology and those perhaps of something higher than this, seem to favour the accuracy of our opinion. But there is still more to be said in favour of the system of gardening which insists upon variety of cropping. In some, if not in many instances, a cottage gardener may have ground sufficient to raise crops more than enough to supply his own wants. Now, as the principle of "likes and dislikes" to which we have alluded applies universally, if our cottage gardener has, as in the above supposed case he will have, extra produce to dispose of to his neighbour, he will be able to secure a sale for all his produce, inasmuch as he will be able to gratify a wide variety of tastes. And it may be taken as a rule with few exceptions to it, that what is the more novel or out of the common way of produce fetches a higher price. And it may happen that some of the better, or at least richer, classes of the neighbourhood, although they have gardens of their own, may, through neglect, forgetfulness, or the influence of the jog-trot style of garden cropping which admits of no variety, not have grown some vegetable of which nevertheless they may be specially fond. And it may happen that our cottager, with his "variety system," may have grown it—in which case he may make sure of getting a higher price for it than he otherwise would. "Fancy things" bring "fancy prices," and these are very beneficial to the purse; and the purse of the labouring cottage gardener is not usually so well filled as to make even an occasional good extra sum a matter of indifference.

Advantages of Variety in Fruit and Flower Culture.

The same principle of "variety" should dominate the selection and cultivation of fruits and of flowers. And as regards the latter, we should earnestly advise the cottage gardener to pay great attention to them. One great advantage which flower cultivation possesses is that while attention to the flowers is required to be continuous or constant—for they must never be neglected even for short periods of time—this attention necessitates no hard work, nor requires the great physical strength which much of the work of vegetable cropping demands. Hence the wife can give occasional help in flower cultivation; and indeed she should, as a matter of health and mental culture, make a point to do something of the flower-plot work. The children, almost the very youngest of them, can also do a great deal of useful work in this way. And with them the physical and mental good to be derived from it is such, that it would be well worth while for the "house-mother" or the "bread-winner" of the cottage to insist upon this work forming part of the discipline or necessary work of it.

But the light work of wife or children given to flower growing and flower tending will pay; and that is a point not in any wise to be despised by the cottage gardener, or indeed by any one, in connection with work done. A true man is thankful for material benefits arising from work done, none the less, possibly all the more so, that he is thankful for the mental or moral ones which flow also from it. And for flowers there is always, and in all neighbourhoods, a great demand, and this demand is ever increasing with the supply—for "flower love" grows by what it feeds upon. Almost the very poorest can afford now and then a penny for a bouquet or a "nosegay,"—and the cottager could contrive to give out of his flower plots a goodly-sized nosegay even for a penny, and a goodly number of them as well—although got out of but very tiny flower plots. We have known instances where the younger branches of the family have, by the sale of the flowers of their little plots during the flower season, stored up as much as bought them comfortable shoes and warm stockings for the drear winter time, when under its biting winds and frost and snow the beautiful flowers die down—only, however, thank God, to spring up again next season as bright and beautiful as ever. Now, "every little makes a mickle," and fortunate the cottager who sees through and through this proverb and learns the wisdom that it teaches. And we know of no system of gardening so suited to the getting in of "littles," as that which has "variety" for its base of cropping, whether that be of vegetables, fruit, or flowers; and simply because the system creates so many littles. And as in vegetables, as we have seen, so it is in fruit and flowers,—one season is not so variously and decidedly bad that it kills or injures every variety of produce; some will be sure to escape, and those some may keep the garden from being a total loss—be, in fact, so prolific that a profit may, even in a bad season for other varieties, be the result.

Detailed Points in Variety of Vegetable Cropping of the Kitchen Garden.—Value of Herbs or Pot Herbs, in the Household, and for Sale.

In connection with this system of "variety in cropping," let us glance at some points which will still further illustrate and enforce its value—a value which from our experience we should be inclined to say can scarcely be overestimated by the thoughtful Cottage Gardener. And what we have to say further may convey something of value to those whose more fortunate worldly circumstances render the possession of large gardens to their houses a matter of positive or comparative ease: to wit, that other class which comes under our title—the Villa Gardeners.

Cultivation of Herbs in the Cottage Garden.—General Remarks.

The first point to which we shall direct the attention of the reader interested in the simple, yet ever pleasing and generally in every way profitable work of the cottage garden, is that of herb culture. Of the uses and the economical value of these some of our readers may not be aware, or fully aware.

To many indeed, especially those resident in the southern parts of the kingdom, much of what we have to say will be nothing new; but to nearly all who reside in Scotland it will be wholly so, as not only are herbs there as a rule unused, but they seem to be disliked by the majority. This is certainly a matter of regret,—not so far as the better classes are concerned, because they have many ways of making up the deficiency; but assuredly it is so, so far as the labourer is concerned, inasmuch as their use tends greatly to the economy of cookery, and also unmistakably to health. Many a toothsome dish can be made out of very cheap materials, by the addition of one of other of the many herbs which can be cultivated even in the smallest of gardens, with as little trouble and as little cost; which dishes would otherwise be very tasteless, if indeed they would be worth the making. To a north-country person it would be a matter of surprise to see the great variety of herbs which are often found in the cottagers' gardens of England, and to become acquainted with the number of ways in which they can be applied, as tempting and healthy adjuncts to various dishes.

The cultivation as well as the use of herbs, indeed, may be said to be almost a science, if such a term can be used concerning what will appear to some to be a very trifling matter; for each dish in many cases has its own particular herb, which is used along with it. No doubt, in many cases the taste has to be acquired, but this we should think would be easily done, as they are almost always delightful addenda to the dishes; and from what we have said about it, the acquirement should be cultivated—and to make a poor pun, so should the herbs themselves—in the cottage gardens of every labourer in which they have not hitherto had a place. (See a chapter on the science of cookery in the series of papers entitled "Domestic Service as a Technical Calling.")

THE MARKET GARDENER.

His Work in Producing in Bulk, Vegetables, Fruit, and Flowers.

CHAPTER I.

Introductory.

We are all apt, naturally, and in one sense legitimately, to overestimate the importance of our own peculiar calling, or business, as that by which we live, and in the progress of which we seem alone to be interested. But, apart from such general considerations as are connected with the relationship existing between the various classes of work by which industry is promoted and the wealth of the people created, the dependence which one has upon the other, the close-set links which bind the whole together in one common interest—the welfare and well-being of the community,—apart from all this, those branches of work connected with the production and the preparation of food for man (and of those the arts of production the first) necessarily take precedence of all the other branches. Necessarily: for man must live,—he works, indeed, to live; "lives to work and works to live," as it has been so well and antithetically put; so that it is absolutely true that all the other arts are subsidiary to those which concern themselves with the food supplies of man. Hence, agriculture has been called "the nursing mother of all the arts," and "ars et artium," the art of all arts. The same may be said, although in a modified sense, of gardening, and more especially of that class or style of it which concerns itself with the supply of vegetables.

Distinction between General and Market Gardening.

The distinction between ordinary, or what is generally known as gardening simply, and market gardening, lies not so much in the fact that ordinary gardening embraces all varieties of culture, fruit as well as flowers, and vegetables as well as both fruit and flowers, as in this,—that even if gardening, as in cottage work, concerns itself only with vegetables, produced in number and individual quality on the small scale fitted as a rule for the consumption of a family, market gardening is, as a rule, confined to the cultivation of vegetables, but those on the largest scale, and that requiring from five up to fifty, and even more, acres of land for their production, in proportion to the demands of the population of the cities and towns in the immediate neighbourhood of which, or as near as can be conveniently arranged, the market gardens are situated. While the crops of the market gardener are comparatively few in number, the bulk of produce of each crop is in all cases large, and in some cases what may with all truth be called enormous.

But in addition to the supply of vegetables on this large or largest scale, commensurate with the great demands for them created by an increased and ever increasing population, there are two other features connected with the art of market gardening to be noticed here: the first is the methods of culture adopted in order to produce crops which come to early maturity; and the second the methods by which crops are taken from the land in rapid and continuous succession.

The Production of Vegetables, etc., Early in their respective Seasons a Special Feature of Market Gardening.

The first of these two features is one brought into existence by the growing love of vegetables amongst our people, and by the natural desire there is to begin as early as possible in their respective seasons to enjoy them in all the freshness of their novelty and health-giving qualities. No doubt, a large element in this matter is that of the emulation of the rich and luxurious of our population one with another—many of whom care more for the fact that they can have at their tables the earliest productions of our gardens, the cost of which elevates them to the rank of luxuries, and the more costly their price the higher in this rank they occupy—which are possibly more thought of and by some envied as such, than from any real gratification of the palate in eating them, or for any benefit they may give in a health point of view. For the earliest of our crops—known often as forced—are by no means the best, either in point of flavour or in the real vegetable value which only proper and what may be called naturally produced maturity can give. Be all this as it may, and be the reasons for the existence of this social fact now noticed true and sound or not, there does exist a strong and in one sense a universally wide desire on the part of the people to have as early supplies of vegetables in their recurring seasons as possible, and amongst the rich the very earliest. And our market gardeners are not slow to avail themselves of the opportunity thus afforded to get high prices for such crops as they can put into the market at the very earliest period of the year in which such crops are, as they are termed, seasonable. To secure this trade some market gardeners take great pains and go to large expense. Some make it a point of pride, to say nothing of that of profit, to be, if not absolutely the first, amongst the first of those who appear in the market with their produce. They, in fact, carry out this principle in business so thoroughly, that they only concern themselves with the growing of the earliest possible crops, and retire from their sending of crops of the same kind into market when their price comes within the category known as "moderate." They may virtually be said to be producers of high-priced early produced crops only; doing little to supply the market with the same crops at what may be called the general period of sale or supply and consumption.

A Quick Succession of Crops another Feature of Market Gardening.

No doubt all market gardeners aim at getting early crops, if only for the reason that if but moderately early they will secure for them higher prices, but chiefly because they wish their land free from them as soon as possible, so that it may be occupied by some other crop which comes next in succession and in popular demand. This, the second special feature in market gardening to which we have alluded, is one to which great and most marked attention is paid in its practice. It is true that taking a succession of crops from the land is a part, or should be a part, of gardening as practised in the ordinary way and on the usual limited—more or less—scale (see "The Cottage and Villa Gardener"). But this principle of succession is carried out in market gardening on a scale and in a way so complete, thorough, and withal so rapid, as to make its practice an almost totally different thing from that which distinguishes it in ordinary gardening. In the market garden the spectator will see men occupied in removing the crop from one end of a plot of land, while he will notice others who will be engaged in digging and preparing it for another crop, while yet others will be sowing the seed for it, or transplanting the plants on the ground already and so rapidly prepared. This quick succession is a necessity of the system of market gardening; and arises not merely from the desire of the gardener to get as quickly as possible into the market the widest possible variety of vegetables, but also from a no less ardent desire to make the most of the land and to reduce thus the cost of its rental. For, from the very circumstances of the case, the rent of land let for market gardening is much higher than that of ordinary or house-garden land, and greatly in excess of that let for ordinary farming. The details connected with these, the two leading features of market gardening, will be dealt with in succeeding chapters, and will, in fact, embrace all that has practically to be given in connection with the art.

The Consumption of Vegetables a comparatively Recent Feature in our Domestic Life.—Brief Notes on the History of the Introduction of Vegetables into England.

Although it may seem somewhat strange to some of our readers, it is nevertheless the fact, that notwithstanding the important place which vegetables now occupy in the supply of the material wants of the people, they are of comparatively recent introduction amongst us. As we have received more than one of our leading industrial arts from the Continent, so also from there did we get our vegetables. And of the Continent the part most famous for its industry, as it was also famous for its art—that, namely, so long known as the Low Countries, now constituting Holland and Belgium—was also celebrated for its highly cultivated farm lands, and for its luxurious and bountifully cropped gardens. And this at a period in the history of western Europe when with us farming did not deserve the name which it now possesses amongst us, of an art based upon science; and when vegetables were almost wholly unknown to us,—not merely not in cultivation, even on the most limited of scales, but not known to the great bulk of the people as articles of food. It was at this period only the very richest who could indulge in vegetables, and those, few in number and exceedingly scanty in supply, were chiefly imported from the Low Countries we have just named. And, from the infrequent opportunities and the necessarily slow transit from one country to another, as well as from the quickly perishable character of the produce itself, it will easily be seen that what very limited consumption there was then amongst our rich people—to whom alone, from its costly price, it was accessible—must have been confined to the Metropolis and to those few ports which carried on the then exceedingly limited traffic existing between the Low Countries and our island.

Brief History of Vegetable Culture—England continued.

As the monks and religious houses were for long and truly "dark" ages the conservators of all which now constitutes our polite or civil learning, so also were they the patient conservators of all which came down from the agriculture and gardening of the ancients, as well as the promoters and introducers—in the first instance—of those garden crops which we now call "vegetables" and "culinary herbs." It was from the carefully, and we may in all truth say lovingly, cultivated gardens of the monasteries, that the knowledge of and the best method of producing vegetables and herbs spread amongst the people, just as it was in the case of the farm lands. A few indeed of the methods, which some amongst us pride ourselves upon as the products of the ability and knowledge of the nineteenth century, were introduced, and long successfully carried out, by the monks. In stating all this the reader will do us the justice to believe that we are only actuated by a desire to give information to some of our readers who may be ignorant of it—to give "honour to whom honour" is really due. It is a poor mind which cannot see, a still poorer which when it sees cannot gladly if not gratefully acknowledge, merit even in one to whom he is opposed. It was only about two hundred years ago that vegetables began to be cultivated for profit—in other words, that market gardening took a practical place amongst our industrial arts.

THE BOAT AND SHIP BUILDER.

OUTLINES OF THE PRINCIPLES AND PRACTICE OF HIS ART.

CHAPTER III.

Buoyancy of Floating Bodies.—Relation of Bulk to Weight of and to the Displacement of Water by Bodies.

IN preceding paragraph but one we concluded by stating that the upward pressure of the water, represented by the arrow *k* in fig. 1, is always equal to the weight of the volume of water displaced by the body, and while the bulk of the body remains constant the pressure upwards will always be constant. But while the bulk or volume of the floating body *e f g h* remains constant, the weight may vary, and that very materially. If the weight of the body, represented by *e f g h*, fig. 1, be equal to the weight of the volume *e f g h* of the water which its bulk displaces, the weight which gives it what may be called a sinking or dropping force, in the direction of the arrow *l*, is balanced by the equal weight represented by the vertical arrow *k*, and which is due to the weight of the displaced water. The two forces being thus equal and opposite, the body *e f g h* floats, and does not sink. But if we suppose now that the body *e f g h*, still maintaining its *bulk* constant, is made of a much denser material than before, its weight is just so much the greater; but the bulk remains still the same, and the same volume of water is displaced as before, and the pressure due to the weight of this is also as before. If we take twenty pounds to represent this, we have in the greater weight of the new body, which we suppose to be forty pounds, an excess of twenty pounds; so that the body no longer floats, but sinks, or sinks deeper, and this to a depth corresponding to the proportion which exists between the weight of the body and the weight due to the displacement of the water by its bulk.

A log of timber or part of a tree of great density or weight as compared to its bulk, say teak, sinks to a certain depth when placed in water; a log or part of a tree of a less dense or lighter character, such as pine, floats, although both logs are of the same bulk. But the reason why the one sinks and the other floats, the young reader will now perceive is owing to the fact that the teak log displaces a *volume* of water the weight of which is less than its own weight, and which has not, therefore, a pressing or holding-up force, as represented by *k* in fig. 1, capable of balancing the force of weight or gravity of the teak, represented by the arrow *l*, while the pine floats for the converse reason: its bulk—the same as that of the teak—displaces the same volume of water as the teak, but the weight of this volume is so much greater than the weight of the pine log, that it has an excess of pushing or holding-up force to spare, so to put the point familiarly, which therefore goes to keep the log floating.

Buoyancy of Solid and Hollow Floating Bodies.

But if we hollow out the solid *teak* log *a* in fig. 2, which sinks, as at arrow *b*, stopping short at the ends, as at *c d* and at *f g*, to prevent the water from entering, we thus alter it and lessen its weight, while we still keep its bulk the same. And this latter being maintained, we have the same pressing or holding-up force due to the displaced water as before. And if we hollow out the log sufficiently, we can so far lighten its weight that this will be so much less than the weight of the volume of water which its bulk displaces, that the log, heavy to sinking before, may float high out of the water. By thus lessening the weight of a body placed in water, we are said technically to increase its "buoyancy." We can even suppose that a solid bar of iron, as at *a*, fig. 3, which would sink instantly if placed in water, because its weight would be infinitely greater than the weight of the volume of water which its *bulk* — small compared to the weight — would displace, might be so hollowed out after the manner of the supposed teak log in fig. 2, and as shown at *b c* in fig. 3. The point here graphically illustrated shows how a vessel made of iron floats as safely, if well designed, as one of wood, and explains, what has been a puzzle to many, how iron—with which is always associated in the popular mind the idea of sinking, absolute incapability to float in water—can be used for a purpose for which light wood was at one time only employed. A vessel or body of exactly the same size and shape

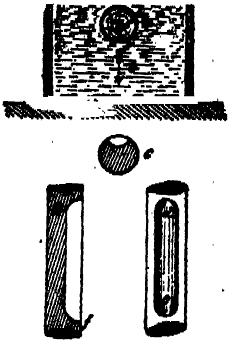


Fig. 2

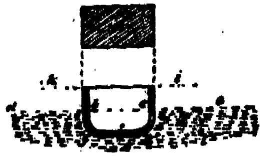


Fig. 3.

as *b c f g* in fig. 3 would float also; but to make it float at the same level or height out of the water as at the line *b c* connected with *d e*, it would require to be precisely of the same weight as the iron vessel *b c f g*. And this weight in the wooden vessel might be got by having its sides very thick, or heavy weights might be placed inside it. Hence it is that an earthenware basin will float at the same level, or, what is the same thing, will sink to the same depth—and this will be in precise proportion to its weight—as a wooden mincemeat or butter-making bowl, provided only that this is of the same weight as the earthenware pot. If one is lighter than the other, the lighter will float the higher out of, or sink the less into the water, and it will displace a less volume and weight of water.

Floating Vessels.—The "Plane of Flotation."—The "Load Line."

The student must keep clearly in mind that it is the actual weight of the body floating in the water which is the measure of the weight of the water it displaces, and is in turn the measure of the upholding force or pressure sustaining the body in the water, or helping it, so to say, to float. A body weighing twenty pounds, pressed or forced into, will just displace twenty pounds of water, whether that body be dense iron or light and porous cork; but, as every one knows, the mass or bulk of the cork will be vastly greater than that of the iron; and, as we have seen, a body displaces precisely the amount of water equivalent to its own bulk, the cork being so much bulkier than the iron, displaces more water; this of course presupposes that the cork was plunged into the water as above named, for under natural circumstances, and considered as a floating body, it would not sink of itself till it was wholly immersed. But to enable a body to float, as in the position at *b c f g*, or in a line coincident with the level of water, *d e*, diagram 3, it must be exactly of the same weight as the volume of water which it displaces; for if it be lighter than the displaced water, it will float the higher. And thus the young student will perceive why, when a vessel is designed so as to float—or, as the technical term is, "to draw so much water"—when loaded with its cargo at a certain line, as *b c*, in relation to the level of water *d e*, it will float just so much the higher when part of its cargo is taken out, and it will then float or rise out of the water so much the higher in proportion as the cargo is removed. The weight of a vessel practically includes everything which it carries, its own weight as well; and the weight of the water which it displaces is always the measure of its weight. We thus have, as already incidentally alluded to, a ready means of knowing the weight of a vessel with all its cargo, or whatever it has "on board," as the technical phrase is. We have only to calculate the cubical contents—cubic feet—of the part immersed, as the part *b f g c*, fig. 3, and multiplying this by the weight of a cubic foot of the water in which the vessel floats, we have in the product the weight of the vessel and all it carries. The weight of a cubic foot of sea or "salt water" is sixty-four pounds, that of river or "fresh water" a little over sixty-two pounds. Hence, as the sea water is the densest, it exercises a higher holding-up or floating power on a body placed in it, so that a vessel which with its cargo floats at a certain height above the water will, if it passes from the sea to a fresh-water river, sink deeper or float lower; and this because the fresh water, being less dense—lighter—than the sea water, has a less upholding or floating power. The line *d e*, in fig. 3, is called the "plane of flotation," and the depth, as *f g l*, at which the vessel floats when loaded with its cargo, gives a line called the "load line," and the height of the sides of the vessel above this line, as between the horizontal lines *d e* and *h i*, is called the "free board." The young reader who has had opportunities of watching the water traffic on such a river as the Thames must have noticed the barges, which have so little "free board" that even the very low waves, as the "swell" from the paddles of a steamer, will wash over the deck from side to side; and he will be able to tell from the extent of "free board" of sea-going vessels whether they are "loaded" with their cargo, or are empty, that is, have only their "ballast" as cargo.

By referring to the early paragraphs of the paper in this Journal entitled "The Technical Student's Introduction to the Principles of Mechanics," the reader will see that all matter, whatever be its condition, whether that which by common consent we agree to call solid, or fluid, or liquid, or aeriform, or gaseous, has its phenomena regulated and controlled by great laws, two only in number—attraction and repulsion. Bodies floating in fluids, of which water is the fluid with which men have practically to deal in doing their mechanical work, are therefore under the operation of the law of attraction of gravitation, and exhibit the same phenomena, although under different circumstances and conditions. The points connected with the centre of gravity (explained in various paragraphs in the paper entitled "The Technical Student in Mechanics") apply to floating bodies with which man has to deal in carrying on the business and supplying the wants of his daily life, in the transport of materials from one port to another by the medium of the sea or of rivers and canals—those floating bodies coming under the generic terms of "ships" or "vessels" and "boats," the power by which boats and ships are passed, forwarded, or propelled from one place to another being either that of oars, sails acted upon by the wind, or of steam. The conditions of safety, convenience of working or handling, and the facility with which changes from one place to another can be made, depend upon three things: first, buoyancy; second, stability; third, speed. It is with the first two we have here chiefly to deal.

Buoyancy and Stability of Floating Vessels or Boats or Ships.

First as to "buoyancy." And here the young reader will again perceive what lessons may be learned or suggestions given by inquiry into the derivation of technical terms. Thus the term buoyancy—by which every schoolboy almost intuitively understands the tendency which bodies have to float or be kept up in or raised out from the water—is derived from the French word *bouée*, meaning a "float," or what we call by a name almost identical in sound and spelling —"buoy," that is, a floating body anchored at some particular spot to indicate the position of some obstacle or danger to sailing vessels. And this word *bouée* is itself derived from *bois*, which in the French language means wood or timber. Just as if in early times our ancestors, having wood so readily at hand, and comparing it with stones and other heavy bodies which sank in water, conceived the idea that wood was the only body which floated, or would not sink—or at all events that this material was the one with which they had in their work chiefly to deal, as compared with stone and iron, and therefore took it as the emblem of the power to float or keep from sinking. We have seen in preceding paragraphs upon what principles the "buoyancy" of a body placed in water depends—the displacement of a volume of water, and the weight of that volume. The "centre of buoyancy" of a floating vessel is a point coincident with the "centre of gravity" of the body or the mass of *water* displaced by the vessel, as the point *h* in diagram 5, presently to be given. It will be seen from what has yet to be stated that this position of the centre of buoyancy flows from or is a consequence of the condition of the forces acting in the case of a body floating in water. The "stability" of a buoyant body or of a vessel floating in water depends, then, upon the relation of the form of the body to the body or volume of water which it displaces. Both of those are acted upon by the attraction of gravitation, or, to use the simple term, gravity, and in both the points connected with the "centre of gravity," as explained in the paper on "The Principles of Mechanics," are illustrated. The reader will there learn how "stability," or the firmness in position (the word being derived from the Latin *stabilitas*, and this again from *stabilis*, which means firmness) of a body normally at rest depends upon the form of the body and the relation of the centre of gravity to the base upon which the body rests—that is, the plane surface forming its foundation. The water in which a body floats is mobile, and therefore easily admits of the change of position of the body; for, as the pressure of a fluid is equal in all directions, as we have already shown, so movement of the fluid in all directions is equally easy; it thus gives way, so to say, in any one direction to a pressure or force exerted upon it as easily as it does in another direction. The water in which a body floats presses equally upon that body in all directions, so that any body which is of the same weight or specific gravity (for this latter term see also the paper above named) as the water in which it floats is at rest in every position, and no matter at what depth of water it may be. The young reader, therefore, who studies what will be given elsewhere in this work under the head of the "centre of gravity," and what has been here said under the preceding paragraph, will see how the stability or firmness of position under pressures or forces acting from either side, and tending to push them over or aside in the directions of the horizontal arrows, will be different in the different floating bodies shown in diagram, fig. 4, the centres of gravity of each being indicated by the points *a*, *b*, *c* and *d*. But we have said that the stability of a floating body depends upon the relation which it has to the body of water which it displaces. We have seen the mechanical advantages of considering that a force such as that of gravity acts upon a single point only in the body, although of course it acts upon the whole body; and this single point is called a "centre," as the centre of inertia, centre of percussion, and the like. We have in like manner the "centre of buoyancy," to which we now direct attention.

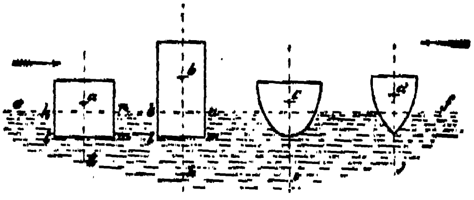


Fig. 4.

The Centre of Buoyancy.

We know that the centre of gravity of any body is found on a line which is vertical and pointing to the centre of the earth. Thus the lines *a g*, *b h*, *c i* and *d j*, in diagram, fig. 4, are those on which the centre of gravity lies. Those bodies, then, are forced, as it were, downwards, or have a tendency to sink in the direction of the lines *a g*, *b h*, etc. But we have said that the volume of water displaced by any body presses (see a preceding paragraph) upwards upon the floating body as on the base *l m* in diagram, fig. 4, with a force equal to the weight of the volume, which is the same in amount as the weight of the floating body.

THE ORNAMENTAL DRAUGHTSMAN.

HIS STUDY AND THE DETAILS OF ITS PRACTICE, CHIEFLY IN RELATION TO TECHNICAL WORK IN MANUFACTURING DESIGN.

CHAPTER VI.

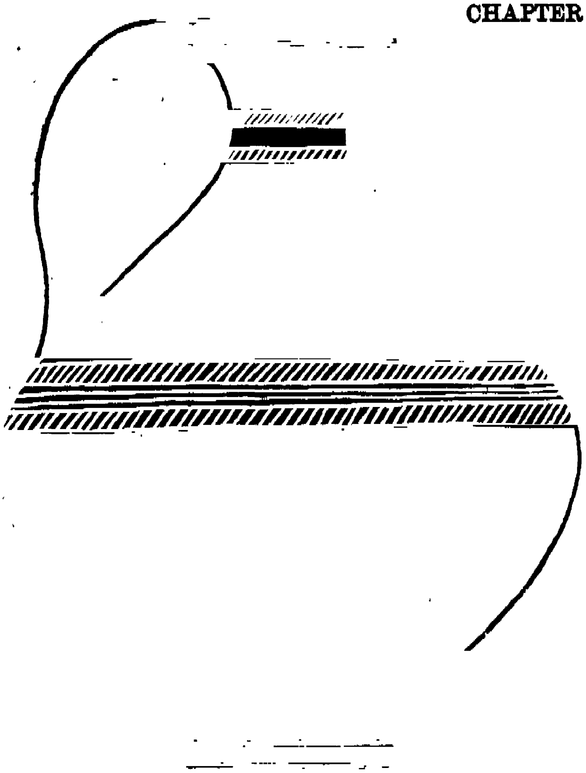


Fig. 27.

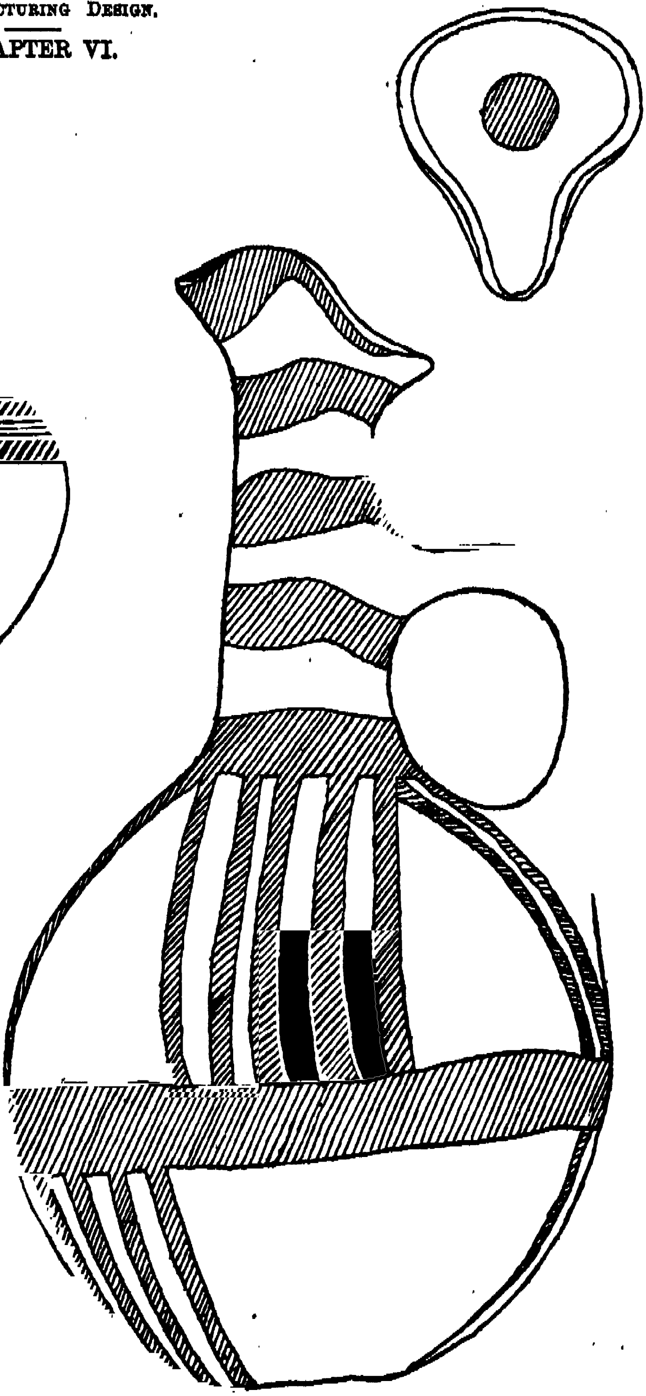


Fig. 28.

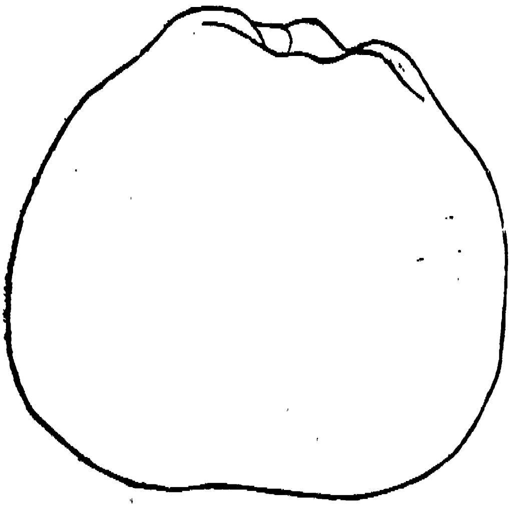


Fig. 29.

Continuation of Subjects for Copying.—Vases and Fruit.

IN continuation of our examples for "copying," and serving also as bases for work in designing of ornamental subjects, we now come to a beautiful simple form of a Greek vase (fig. 26 *ante*, p. 201), which it is hoped the student will very carefully draw, and study the form. It is drawn the size of the original, as is fig. 25, and like it is made of light red earth, and unglazed.

Fig. 27 is a small Phœnician vase or jug with one handle. It has two lines round the neck, and two more below the handle; there is also a line running round on the flat part of the top; they are of a brown colour, the clay is a warm drab. Fig. 28 is also a Phœnician jug, but very dissimilar to the last; the neck is decorated with irregular bands drawn round it, while the lines on the body are vertical, running into a broad band round the middle of the jug, and not continued below it, the lines below alternate—that is, there is blank space below and above the vertical lines. It is drawn the same size as the original, and *a* shows plan of upper surface of mouth. Figs. 29, 30, 31, and 32 are outline drawings of fruit from nature, which we hope the student will very carefully copy. Figs. 29 and 30 the apple, side and top view, fig. 31 a lemon, and fig. 32 a pear.

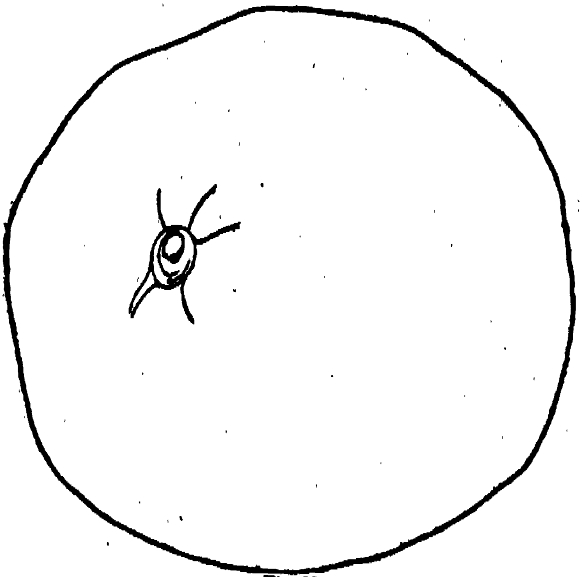


Fig. 30.

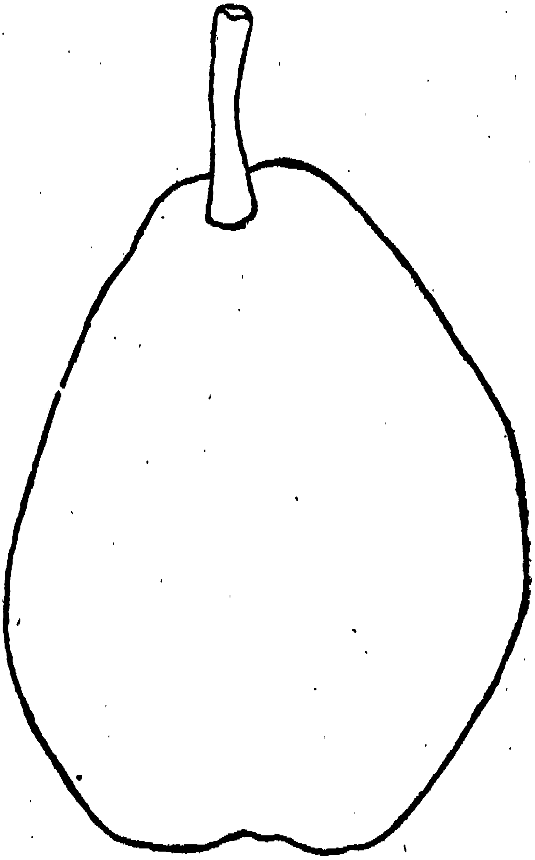


Fig. 32.

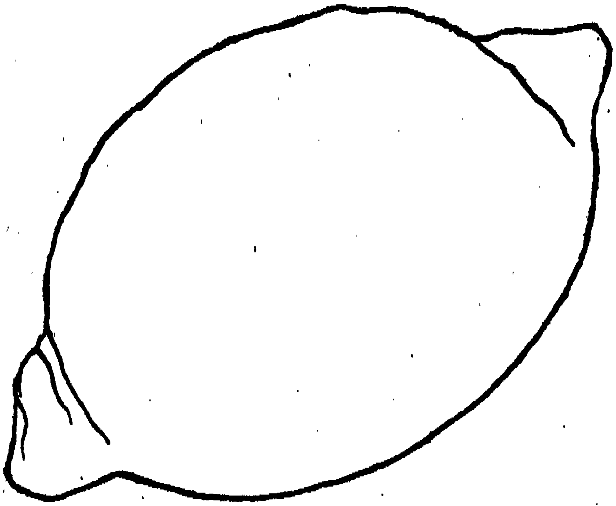


Fig. 31.

The Student's First Studies in Ornament.

Figs. 33 to 38 inclusive bring before the student his first study of ornament. Figs. 33 and 34 are the well known moulding called the "egg and tongue," or "egg and dart," in ordinary practice; in architectural works and in lectures on ornament it is called the "echinus" moulding.

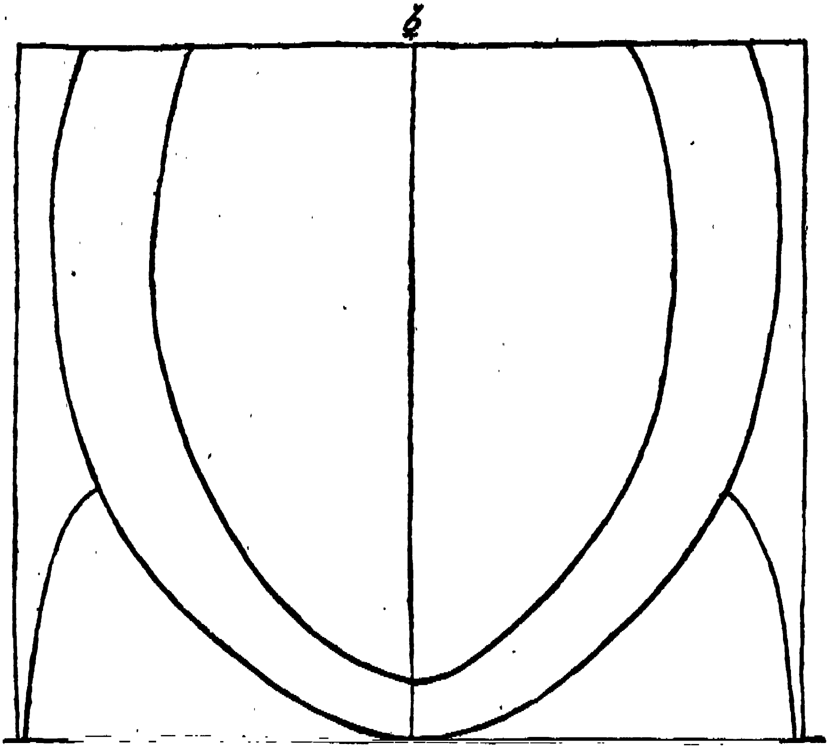


Fig. 33.

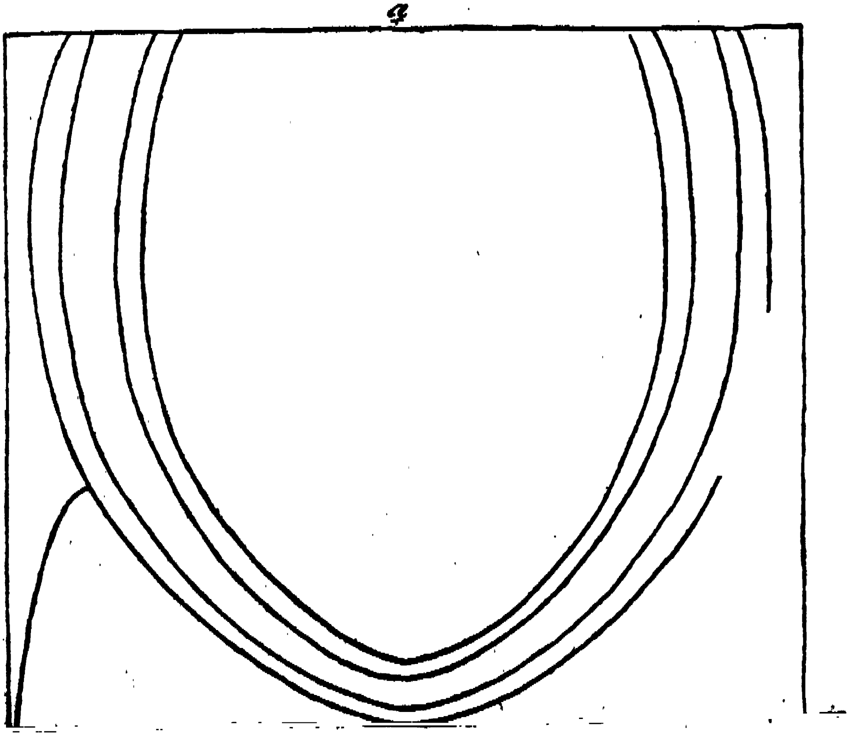


Fig. 34.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER V.

IN continuation of the early history of the shorthorn breed, in the last paragraph of the preceding chapter, we have now to note that the place next to Bates, and as many maintain, in precedence of him, in the practical work of breeding was taken by the great rival to his fame—John Booth of Warlaby, whose career also as a great prize-winner for improved shorthorns began when, or about the time when, Bates had retired from the scene of his triumphs in this direction. The Booths as a family had long been held by the farming public, especially that of Yorkshire, as shorthorn breeders of distinction. The herds of Killerby and of Warlaby, destined to become so celebrated, and the founders, so to say, of a school—that of the "Booth blood," the adherents of which still keep up a rivalry more or less keen with that of the opposite camp, the "Bates blood"—were founded so early as the year 1790 by Thomas Booth of Warlaby, who at that period had cows of the breed of a very high class, though, like some of the animals of other breeders, they could boast of no recorded "pedigree." But Booth got for his herds one of the best bulls of Robert Colling, and hired other well known bulls of the Bampton breed. At the Ketton sale of Charles Colling's herd, already alluded to, he purchased, for no less a sum than two hundred and seventy guineas, the bull "Pilot," of the "Wellington" strain, and this animal turned out to be one of the best bulls Booth ever had. After this he always bred the bulls in his own herd from this blood. His sons Richard and John took up and followed out the breeding which their father had inaugurated. Richard, after his father's death, removed to his father's farm at Warlaby, and took up the herd which had there been established by his father. John farmed at Killerby, at which place, with his father's experience and help, he established a herd. In 1834 Richard sold his herd, and his brother John began soon thereafter to take up the highest position as a prize-winner of the breed, from which position he retired in or about the year 1857. Of the founders of these, the two great modern schools of shorthorn breeding, Bates went in for fineness, indeed elegance of general form, and spirited, or what is called high-bred or fine action—that is, *pose* and gait; the Booths made their great points compactness of frame, with great depth or thickness of flesh, the high development of the fore flank being a marked peculiarity of their best bred animals. Time and space both failing us, we regret exceedingly that we cannot give any of the details of the work done by, nor note the various steps in the progress of the great breeders we have now glanced at. Those of our readers who are anxious to know more than we have given will find a vast deal of most interesting information, both as regards historical and practical points, in works specially devoted to the branch of farming connected with live stock or with cattle. We proceed, therefore, to take a somewhat detailed glance at the

Peculiarities or Physical Characteristics of the Shorthorn Breed of Fattening Cattle.

The shorthorn ox of which we gave an illustration in fig. 1 (see preceding chapter) is pre-eminent for his fattening capabilities coming to maturity at a very early age, giving the largest yield of saleable meat at the lowest cost. His frame is large, with all the points well set and developed, most favourable for the laying on of beef, giving the best and finest cuts. The legs are short and well set in the frame, giving a full development of the chest and vital region; the bone of the fore-leg below the knee fine and well turned, and where it joins the body at its upper part the fore-leg—technically called an arm—broad and tapering, merging into and level with the girth. The hind-legs should be straight, or nearly so, and well placed under the body. The set-on of the legs in conjunction with the well-developed frame of a fine well-bred shorthorn give a stateliness of general dimension—in its pose and walk what horsemen would call "fine action"—which is looked for in those who choose good or the best animals. The head should have a tapering muzzle, broad open forehead; while the placid and prominent eye is always a marked feature of the breed. The head should be set well on the neck, and this not too long, and merging gradually into the shoulder. As already stated in the preceding remarks on form in cattle, the general appearance of the frame is level, with uniform—not patchy—development of flesh. The setting-on of the tail in the manner yet in a future paragraph to be described and illustrated is always a point looked at in the shorthorn; but while this is a *sine quâ non*, and so set that it gives the square form to the animal at the twist, and giving side bones of height sufficient to carry the flesh well up to the level of the quarter, there should not be any marked redundancy of development which makes the separation of the rump from the quarter a marked feature. The hip-bones should join the quarter and false ribs so gradually, and be merged so completely and without any marked feature, that it should not be easy to point them out. The colour of the shorthorn varies much, from a pure white to reddish-yellow, and patched or spotted or marbled in red and white, a red roan or bright red, or a spotted roan. Some object to the pure white colour, but if this be chosen by some it is considered as an essential that the muzzle or nose be black: a pure white in colour with a red nose would be put out of court at once by some breeders, while *any* black on a shorthorn would be so by others—and this was a point of belief among the early breeders—being considered as the mark or evidence of a decided taint in the blood (see a remark on this point below). It may be interesting to give here the description of the characteristics of the shorthorn as accepted by the best of the breeders at the end of the last and the beginning of the present century—by which time, as we have seen, the breed had been established in its modern form, and many celebrated animals existed by which its fine characteristics were remarkably exemplified. The following is by the authority we quote:—"The many judicious breeders, who have immediately succeeded each other, glowing with increasing emulation, have brought the stock now to a pitch of excellence that was never before known in any breed of British cattle, when the accumulated points of perfection are considered, whether as to beauty or profit. Such is pretty well demonstrated by referring to an extract of Mr. Charles Colling's sale, in which it appears that forty-eight head of this highly cultivated stock, bred by himself, fetched £6067." "The shape is now brought," says our well informed authority, "to a high state of perfection: a straight back, springing ribs, and fat loins (consequently the hip bones, though broad, scarcely appear to project), a fine thin head, light neck (not too long), deep in the brisket, broad in the chest, round barrel, with fine bone, and so gimp or light in the belly, as, in some instances, to appear high on the hind-legs. This is a very distinct point in the breed—a shape quite contrary to a hollow back and swaggering belly, common in bad-shaped animals. The hide possesses a certain mellowness that indicates the best quality. In respect to colour, there are many fine beasts of this breed quite white. Such is a celebrated Martin heifer, which is now travelling as a show, and which, as an example of fatness, was never excelled. Mr. Neasham's celebrated ox is white; also 'Lily,' bought by Mr. Rubb. The external white of these cattle rises out of a golden pile next the skin, which gives a very rich and mellow appearance. The muzzle is uniformly flesh colour; any black, even a single spot, would throw suspicion upon the purity of the blood. The horn, which is small, is yellow, as are the hoofs. The colour now most esteemed is the white and brown mixture; yet there are many distinguished individuals of red, and red and white; black, as has been observed, is absolutely ill bred, whenever it appears."

The Hereford Breed of Fattening Cattle.

This, which is one of the most esteemed of the breeds of fattening cattle, ranks, in the opinion of many, as second only in meat-producing value to the shorthorn. Indeed, in view of the superior table-excellence of its flesh, possessing the fine intermixture of layers of alternate flesh and fat so much esteemed by epicures, it is considered by many to be superior, as a "butcher's beast," to the shorthorn. Be this as it may—and in this, as in nearly every other point of practical grazing, the saying "many men, many minds" holds good—there is no disputing the high value of the Hereford breed. It owes its name to the county of Hereford, which is the peculiar *locale* of the class. That the Hereford cattle are an aboriginal breed or race, indigenous to the soil of the county from which they take their name, are points deemed by the first authority of the day on all matters connected with the breed—J. Duckham, Esq., M.P.—to be beyond all dispute. Did space permit, we should like much to give here a variety of most interesting information respecting the breed, from which, amongst other points, it would have been seen that it has enjoyed a distinct and decidedly high reputation as a fattening breed for certainly the whole period of the present century; though it would be easy to prove that they possessed a very distinct place in the regard of the grazier, and through him the butcher, for a period considerably anterior to the beginning of the century. When, in the year 1845, Mr. T. C. Eyton began the work of forming a "Herd Book," or pedigree record as it may be styled, for the Hereford breed, in order to arrive at correct conclusions he found it necessary to divide it into four classes of animals, each having its own physical characteristics as regards the colour of the face chiefly. Those four classes were—first, the "mottle face"; second, the "dark grey"; third, the "light grey or white"; and fourth and last, the "red with white face." But now the breed is almost universally characterised by the last-named feature, "the red with white face," a curious instance of how a certain class of peculiarities are by the breeders made to dominate others, and also how quickly this may be done. For it is worthy of note that a period of activity not exceeding a quarter of a century sufficed to extinguish practically the three first classes named above, leaving the last master of the field, and so completely that when animals of the first three classes are exhibited they are set down by those who do not know the early history of the breed as anything but fine specimens of it. Let us now glance at some of the points connected with the breed, an illustration of which we give in fig. 2. The parts which are white are the face, throat, chest, the lower part of the body, the top of the tail, and the crest; so also are the lower parts of the legs. The expression, countenance, or face of the animal is fine, placid, and open; a small red spot on the eye is looked upon by some as a marked evidence of good breed, as also a circular spot of red in the centre of the white part of the throat. The horns of the bull or steer spring straight out from the forehead; those of the cow are most delicate in form, with a lateral or sideways direction, curving slightly backwards, forwards, or upwards, with the points turning in as if meeting or tending to meet over the centre of the forehead. In both the horns are in colour yellow or white, clear and waxy in texture. The head is small when the bulk of the body is considered; and the eye is quick and lively, yet conveying placidity of temperament—one of the first requisites, as we shall hereafter see when we come to describe the details of breeding and feeding, in an animal which should fatten quickly. The cheek is fine; muzzle white and fine. The bosom is prominent, in good proportion, and the chest deep and full. The ribs are deep and well sprung or rounded, and level with shoulder point. The shoulder-blades are flat, thin, and so well do they merge into or blend with the body, that it is difficult in a high-bred animal to indicate the points where they commence or set-on. The legs are straight and small; the rump in a straight line with the back, and at right angles with the vertical line of thighs; the tail well set-on (see a succeeding illustration under the head of "Breeding"). The coat or hide is thick, yet giving a fine and mellow touch; the colour of the hair red, with fine glossy tint, and having a tendency to curl or be wavy. As entering more in detail, and as also giving the reader much information on points in fattening cattle generally, we here give from a high authority the following description of what a good fattening Hereford animal should be:—

"The face should be long and taper, the middle of the forehead broad, and rather inclining inwards, which is effected by the hollow of the skull that contains the eyes being rather projecting; the eye-balls prominent and brisk; the lids thin and well stored with eyelashes, which, as in the human species, give a general expression to the features. The setting-on of the head and neck remarkably fine and elegant, and afterwards progressively leading down to a full and deep bosom, guarded on each side by the points of the shoulder, being neatly let into the line of the neck, and inclining rather upwards, so as to produce the even appearance which is so striking in the Herefordshire cattle, beginning at the closing of the shoulders, and running all along the top of the chine. If a contrary shape occurs, and the points of the shoulders push downwards, the consequence is evident: the neck appears out of proportion; the weight or strength which ought to be in the closing or junction of the shoulders at top is destroyed; and the end of the chine at that part is thin and hollow, so that the whole frame forward is completely deprived of that due symmetry it ought to possess. The ribs, all the way from the part just alluded to, should begin pretty early to project after its junction or springing forth from the backbone; and this effect is more especially necessary in what we call the first rib, or that nearest the hip, which cannot be too broad and projecting, and should be pretty near the hip or free-bone. By this early inclination to project, the upper part of the ribs support a full chine, which is of as great value as any, in the scale of provision, and cannot bear an equal apparent weight, in a flat or weak-sided cow or ox; and by the first rib and hip coming near altogether, the under loin is kept up and supported to the hand of a skilful judge, which, though a beast may be fat, cannot be equally the case where these two parts are far asunder, and there is a disproportionate vacuum.

"I next come to remark the situation of the hip

Fig. 2.

bones, which I look upon to be the most essential parts to add beauty, weight, and value to every sort of beast that comes under the description of horned cattle. These cannot stand too wide, or in my idea too high on a level with the top of the back, running straight for the two extremities. The distance to the point of the rump should be long, taking the aitch-bones upon as exact a level as possible; for where these project, or come out at all so as to equal the prominence of the hip, it is impossible for a beast to come well to handle, as they will be hard and similar to most bulls to touch, and cannot get fat in those points most requisite to make a fat animal desirable. The point or ends of the rump on each side the tail should when poor be well supplied with loose skin, and be soft so as to allow room for expansion, as the creature progressively fills out in feeding; and these points should stand rather high, so that the root of the tail may be guarded on each side; for when this is not the case, and the points of the rump are low, the tail stands high and disfigures the animal, and they seldom are so well inclined to load with fat on that part. There are gristles at the setting-on of the tail, which should rather project on each side, even when cattle are poor, as I have ever observed they accumulate much more fat in this part, which is very essential to the sale of a beast. These cattle are generally short, and full in the thigh; for where they are of a contrary shape, they never fill out well in the twist, or that part leading from the tail to the udder of a cow, which is of infinite consequence to the weight of the round of beef, after the animal is slaughtered.

"Let it be observed, that the bone being small below the knee and hock is a singular perfection; and it commonly happens that the fattest animals have the most slender bones to support their weight."

The following gives the dimensions of a good specimen of the best of the earlier breeds: Length—from the rump to the extremity of the hip-bone, 2 ft. ½ in.; poll to the tail, 7 ft. 6 in.; face, 1 ft. 9 in.; horn, 1 ft. Height—from the ground to the dewlap, 1 ft. 6 in.; to the brisket, 1 ft. 8 in.; chest, 2 ft.; of the hind-quarters, 4 ft. 7 in.; shoulders, 4 ft.; knee, 13 in.; hock, 19 in. Breadth—across the face, 11 in.; the hips, 2 ft. Girth—round the chap, 1 ft. 10 in.; cheek and forehead, 3 ft. 7 in.; neck, 3 ft. 5½ in.; chest, 6 ft. 9 in.; knee, 14 in.; bone of fore-leg, 8½ in.; bone of hind-leg, 9¼ in.; coronet of fore-foot, 15 in.; of hind-foot, 13½ in.; hock, 17½ in.; horn, 10 in.

The Devon Breed of Fattening Cattle.

This is the third in our list, but not the least esteemed by some breeders—who place it, indeed, the first in their list, from the high quality, the "juicy" nature of its flesh (see fig. 3). The best and purest specimens are met with in North Devon. They are small animals as compared with bulkier breeds, but they have so fine an action, or elegance, in their movements, that they have been called the "ponies" of the breeds of fatting cattle. They are peculiarly well fitted to make the most of the feeding obtained from the hilly and cold pastures of their native county, and give a quality of butcher's meat from them of so high a character that it stands second to none in the estimation of the butchers of London. The South Devon is a larger and somewhat coarser breed than the North Devon, it having its origin in a cross of the pure North Devon with a larger breed called the "old Marlborough red." A cross of this with the South Molton breed is said to give finer results than when the pure South Devon is used. The colour of the North Devon is red, or a medium red, the coat or hide being peculiarly fine and silky, with a tendency to curl, when the animal is in good condition.

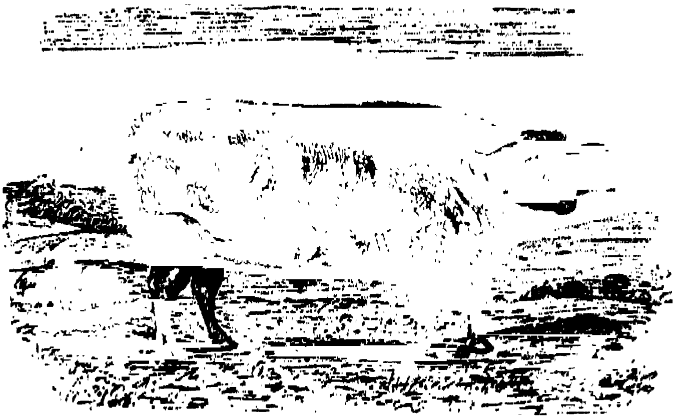


Fig. 3.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER VI.

WE now proceed, as promised in last chapter, to point out how the printing machine works. And in doing this the first point we take up is

The Cylinder "Lapping."

The cylinder, or printing surface, as we have explained before, is wrapped several times round with thick finely-woven cotten or linen or woollen fabric called "lapping," to the depth of about half an inch. This cloth must in all cases be of the best description as regards material and weaving, as, owing to the enormous pressure and grinding or friction that is brought to bear upon it, inferior lapping does not last long, and causes loss of time by necessitating the printer renewing it frequently.

The durability of the lapping made use of, however, depends, to a great extent, upon the skill and care of the printor in its adjustment. Lapping, if badly put on, is apt to shift and tear, which causes serious loss, as the machine has then to be stopped, and sometimes, to put matters right, the rollers require to be taken out.

The first point a printer looks to in beginning his work, therefore, is to adjust the lapping. Next the lapping runs the *blanket* or finely woven thick woollen cloth, forty or fifty yards long, the ends being carefully sewn together by fine woollen thread, so as to avoid a thick seam and form an endless web. Instead of woollen cloth, the Mackintosh blanket is now generally employed; this fabric consists of several layers of calico cemented together by solution of india-rubber. In the latest modern machines the blanket is entirely omitted. These being properly adjusted, the mandrels are fitted into the copper rollers, the necks of mandrels placed in their bearings, the box-wheels are next fastened to the mandrels, and the whole screwed loosely against the printing surface.

Pitching the Rollers.

If there are two or more rollers in the pattern, the pitch-pins or guide pin-points in the rollers are then looked for, and roughly placed in position so as to fall one on another, so that the different parts of the design fall in their proper places, according to the printer's judgment—which is an art attained only by long practice. If the engraving is good, this may be done very accurately.

These "*pitch-pins*" or guiding points are simply pin-holes made on the surface of the roller during the processes of engraving, in order to show the fitting of one colour with another.

Adjusting the Doctors, etc.

The rollers being pitched, the colour-boxes are now placed in position immediately below the rollers, the *furnisher* pressing against the copper roller with the proper degree of pressure. The *lint-doctors* are now fixed on the opposite side of the roller to the clearing doctor. The *colour* is placed in the *boxes*, and the *doctors* are put in position; the printer adjusts them so that they press perfectly "true" on the roller; the weights are then placed on the *doctor levers*, according to the weight which the thickness of colour being printed demands, and according as it is required that the colour should or should not show on the other side of the cloth. The "*back-grey*" is next drawn in—that is, a piece of unbleached cloth running between the cloth to be printed and the blanket (which runs *with* it), for the purpose of keeping the edges of the lapping clean. The large screw which moves roller, colour-box, and doctor, is next adjusted, so as to press roller against cylinder as required, and the machine is put in motion. The printer stands in front of the machine, screw-key in hand, and as soon as the impression appears upon the grey, he stops the machine and examines the impressions produced by the various rollers, and shifts the rollers by means of the various screws already described, until, by again starting the machine, and repeatedly adjusting the rollers, the various colours of the pattern are all in their right positions, so that the impression on grey agrees exactly with the design. This being accomplished, the white piece, for printing upon, is next drawn into the machine, which of course now does its work. Generally at the beginning of the white cloth is sewn a short piece of cloth, called a drying or trying piece, which is for the purpose of seeing whether the extra thickness of cloth thus introduced will cause a slight difference in the fitting, and if so, it is adjusted, and the printing proceeded with. After the printing machine is started, the printer should not leave it, but should stand in front of the machine, screw-key in hand, and by shifting first this roller and then that, as they are disturbed by thin and thick places in the cloth, keep the printing as nearly absolutely correct as possible.

"Misfits" of the Rollers.

Notwithstanding all the late improvements in the details of the construction of the machine, and "allowances" made in the engraving, slight "misfits" cannot be wholly overcome. These minute and frequently unavoidable inaccuracies, technically known as misfits, are caused by a variety of complicated circumstances, and to compensate for them by "allowances" in the engraving of the rollers in many-coloured designs is one of the triumphs of modern printing.

Back Tenting.

The back tenter is the operative who stands at the back of the printing machine, and whose duty it is to guide the white piece of calico straight, and without scrimps or double edges, and keep it at a regular distance from the edge of the lapping. The back tenter has no help further than bars and scrimp rails, between which the cloth runs, and is thus stretched; and also a *break* upon the end of the axle which carries the roll of cotton, or arrangement keeping the cloth at a uniform tension by compensating for the difference in rate of revolution of axle, which of course takes place as the roll diminishes in size. In other words, the break slackens the axle in proportion as it is required to revolve quickly, owing to the diminishing roll of cotton on it, in order to meet the supply of cotton to the machine.

Allowance for Elasticity of the Calico.

By the modern methods of bleaching and shearing, the calico is rendered so elastic that, if not kept regularly tight, it would gain or lose between the first and last roller, thereby causing a misfit. Even with every precaution and care there is always a certain amount of stretching of the cloth between the first and last roller, and an allowance is made for this in engraving the rollers, so that, for example, the circumference of the last roller, in a many-colour machine, is made a shade *greater* than that of the first—the entire engraving of it being of course proportionately enlarged in the direction at right angles to the axis of the roller.

Importance of the Back Tenter.

We need not enter into the details of the routine of the back tenter's work, such as taking out the rollers, etc., since this would have no interest for the untechnical reader: suffice it to say that he is as indispensable as the printer himself, and that it is almost as important a point to have a good back tenter to any machine as to have a good printer, more especially in the case of machines of many colours.

The Back-Grey

is wound on a beam turning in a frame at the back of the machine, and *behind* the spot where the back tenter stands during the working of the machine. After passing through the machine, the back-grey separates from the printed cloth, a small wooden roller being between, and after drying passes again to the back of the machine, and is wound upon an axle in the frame, and when the first beam with its roll of grey cloth is nearly exhausted this second one is lifted in its place.

Drying after Printing.

When the newly-printed calico leaves the machine the colours are, of course, moist, and require to be thoroughly dried before undergoing any further treatment. The old method of doing this was to pass the cloth through heated rooms; but this has been entirely superseded. The drying apparatus now employed consists of a number of closed wrought-iron tall steam-chests, about 1½ in. thick, with ⅝ in. cavity, through which passes high-pressure steam. Shortly after the cloth is printed it passes up through an opening in the roof of the printing-room, above the machine, into the drying-room, and passes just over, but not in contact with, the large steam-chests, the unprinted side being next the surface. It passes thus over a very large drying surface until quite dry, or nearly so, after which it may without danger be passed over with the printed side undermost. Since the colours must be perfectly dry before passing from the printing, it is essential that the steam-chests be large enough to completely dry the cloth when passing over them at the quickest speed at which the machine prints. Hence the drying arrangement must be able to keep pace with full-speed printing. The printed calico now passes down into the print-room at the back of the machine, and is folded straight by a simple folding motion watched by a boy. The back-grey is generally dried separate from the calico, over a large drum steam-chest, from which it passes down to the back of the machine by a different opening to that of the printed piece, and is received on an axle as before explained. The back-greys are generally used two or three times without washing; but of course this depends on the nature of the colours printed, and on the amount of colour printed on the cloth. The back-greys are then washed and bleached and used for printing.

The Driving of Printing Machines.

New printing machines are now generally erected with a separate engine to each machine, so that the printer can get any required speed to suit the pattern. This is a great improvement in modern calico printing; all old machines were driven by shaft and cogged gearing from the ordinary print-works engine, and by an arrangement of different-sized cog-wheels three speeds could be commanded—the slow, medium, and quick. The starting of the machine, however, causes violent jerks, which shake the whole machine, and sometimes cause the rollers to shift; which is entirely got rid of by the use of separate engines.

In our next chapter we shall proceed to describe the different prints and styles adopted in the practical work of calico printing.

THE COLOUR MANUFACTURER.

WITH PRACTICAL NOTES ON THE USE OF PAINTS AND DYES IN DECORATIVE WORK.

PART FIRST.—PIGMENTS.

CHAPTER II.

White Lead: Its Composition, etc.

WHITE lead is a compound of somewhat variable composition, as may be judged from the many distinct qualities to be found in the market. Essentially dry white lead is a mixture of carbonate of lead, $PbCO_3$, and hydroxide of lead, $Pb(HO)_2$. It is a pigment of great whiteness, opacity, and weight; hence it forms the best white, possessing great covering power and body or density. It is used as a white, and as the foundation or body of many other pigments; thus, it is mixed with chrome yellow for a light shade, or with chrome green for the same purpose.

White lead is very poisonous: taken in small doses, either into the stomach or through the skin, it causes the well-known disease of lead colic, and in larger quantities proves fatal. The usual remedy for lead poisoning is, we may add, the cautious use of very dilute vitriol, or sulphuric acid, which, decomposing the carbonate and hydrate, forms sulphate, which is a harmless compound, or comparatively so. White lead blackens when exposed to sulphuretted hydrogen gas, which is given off by the combustion of coal containing sulphur, and frequently contained in coal gas.

Manufacture of White Lead by the Fermentation Process.

When lead is exposed to the damp air for some length of time, it becomes coated with a white layer. This is white lead. Its formation is greatly facilitated by the presence of acetic acid or vinegar. In this the carbonic acid of the air effects the conversion of a portion of the metal into the carbonate and hydrate. One of the methods for the commercial production is an application of these facts, which is still largely carried on in this country and abroad, although mostly superseded by the later and better processes.

A series of brick chambers or stacks, which generally measure about 25 feet long and 14 feet broad, is employed. Two sides of each stack are provided with a door for the filling and emptying. The floor of each is covered with a layer of porous ashes. On the top of this is laid a bed of spent tan. Above this are placed blocks of wood about 16 in. diameter, and earthen pots between them, resting on the tan, and so supported by the blocks. The pots are placed close together over the entire layer, except a space of about six inches along the sides. The pots are filled with dilute acetic acid or weak vinegar, containing ½ to ¾ of 1 per cent. of acetic acid, $C_2H_4O_2$. Narrow boards of wood are now laid on the top edges of this layer of pots, and on them a layer of thin sheets of common lead to the depth of 5 or 6 inches. A few inches higher there is a wooden shelf bearing another layer of tan, and a similar arrangement of blocks of wood supporting a layer of pots containing dilute vinegar. Ten or fifteen similar layers—first shelf holding a layer of tan, then pots, then lead—are built up on the top, until the roof of the building is reached within a few feet. This being done, the space of six inches left between the walls and pots is filled with clean straw. The doors or stack holes are closed, and the building completely closed in, except where ventilators are provided by which a limited change of air takes place. The building is now left undisturbed for several weeks, after which the doors are opened and the white lead formed is carefully removed to the washing cisterns. Before following it farther, we will now inquire into the chemical changes which have taken place whereby the sheets of lead have been converted into white lead.

The Theory of White Lead Making.

It is well known that lead exposed to damp air soon becomes coated with a white powder. This is the "white lead," the production of which on a commercial scale we are now treating of. The air always contains carbonic acid and moisture, and it is these that cause the surface of bright metallic lead to become white, by converting a portion of the surface of the metal into carbonate and a portion into hydrate of lead. The fermentation process of manufacture is an application of these facts. The slow fermentation or rotting of spent tan gives rise to a large amount of carbonic acid and water-vapour, accompanied by a considerable amount of heat, under which conditions the thin sheets of lead laid in the "stacks" quickly become converted into white lead; the action being much accelerated—as found by experience—by the presence of acetic acid vapour.

The Practical Yield of White Lead by the Fermentation Process.

The amount of metallic lead which is actually converted into white lead each time the stacks are in operation does not exceed, as a rule, 60 to 70 per cent. of the charge. The use of thinner sheets of lead, and a more careful disposition thereof, does increase the yield from 5 to 10 per cent., but this is not usually done in practice. The lead unacted upon is used up in the next charge. A stack covering an area of 20 × 12 feet, and holding 13 layers of lead, requires from 40 to 45 tons of lead to fully charge it; which after the process weighs from 48 to 49 tons, or an increase of 20 per cent. Each layer of a stack of the above dimensions requires about a thousand pots 5½ inches diameter containing the diluted vinegar.

The Milner or Oxy-Chloride Process of White Lead Making.

The fermentation process of lead making may be said to be now superseded by the more expeditious and more accurate process known as the Milner or oxy-chloride method—which latter occupies less than two days, whilst the former requires several weeks. The writer was informed by a very large white lead manufacturer that this process, which he had employed for some years, was cheaper, cleaner, and in every respect more satisfactory than the older method.

When certain proportions of litharge or protoxide of lead and common salt are ground together in a mill with water, an oxy-chloride of lead is formed, together with caustic soda. The former lead compound by the action of carbonic acid is converted into white lead. The commercial process is an application of these facts. For every 780 lb. of dry flake litharge, 98 lb. of common salt dissolved in 150 gallons of water are placed in a wooden pug-mill, made of pine or elm, and the mixture is continuously ground together for three hours. The mass gradually thickens until a point is reached when it begins to become of thinner consistence, which is indicative of the completion of the reaction. The white paste is now run into a large cylindrical iron "carbonator," which is lined with sheet lead and provided with large wooden agitators or paddles. The agitators are now set in motion, and a stream of carbonic acid gas forced into the pasty mass from a pipe passing through the bottom side. Shortly after the mass ceases to be of alkaline reaction, the stream of gas is stopped. The exact point at which the carbonic acid supply is cut off is one of great importance, as upon it much of the quality of the finished product depends—either too much or too little carbonic acid is injurious. The gas being stopped, the white mass is run into large settling tanks and subjected to a series of washings by decantation, by about eight tanks. The water from the seventh washing runs into the first tank, which is run off and fresh water run into the others. The water from the last tank is run into the second. The white lead being thoroughly washed in this manner is subjected to grinding, in order to reduce to powder the lumps which the washed product always contains, and is then dried, when it is ready for the market.

Valuation or Testing of White Lead.

If the white lead to be tested is mixed with oily or resinous matters, these must be completely removed previous to examination for impurities. The best method to effect this, as a rule, is to extract with ether. To ascertain the value of a sample of white lead it is not necessary to have a full chemical analysis of it; and even if it were desirable, it alone would not determine the value of the material for practical purposes. The usual method of testing is simply to mix some paint with a weighed portion—say 1 lb.—of the sample, and to take the same weight of a good standard sample of white lead, both mixed in exactly the same way, and to paint an equal surface of wooden board with these two paints, using in each case the whole of the paint mixed. When dry, the two white boards are compared, and the observation is made whether the sample is as good as the standard. This comparative test shows the whiteness, covering power and density of the sample, and also whether it differs in drying properties from the standard. This method of testing, when combined with the following simple test, will be sufficient to judge of the value of samples of white lead. To test for baryta white, or gypsum, or china clay, the sample, either dry or mixed with water, is warmed in a test tube with dilute nitric acid, when the lead will completely dissolve with effervescence, leaving undissolved a white powder if any of those three foreign bodies be present. Many white pigments in the market—for example, those known as Holland, Venice and Hamburg whites—are mixtures of white lead and baryta white.

To distinguish sulphate of baryta from sulphate of lime the residue insoluble in dilute nitric acid is thoroughly washed with hot water and boiled with a strong solution of carbonate of soda. By this treatment sulphate of lime is converted into carbonate, whilst baryta sulphate is unacted on or not appreciably. The residue is thrown on a filter, and washed until perfectly free from the soda salt. Dilute hydrochloric acid is then added to the residue. If effervescence occurs, sulphate of lime was present. The acid filtrate is made alkaline with ammonia, and oxalate of ammonia added; white precipitate confirms the presence of lime.

Objections to the Use of White Lead as a Pigment.

The two objectionable qualities of white lead paint are well known and well disliked—namely, its poisonous nature, and its property of darkening when exposed to fumes containing sulphur. A third disadvantage possessed by white lead as compared with zinc whites is its tendency to lose its colour in course of time; but as to this defect we have already referred, we shall pass over it here, and treat only the other objections.

Lead compounds, including white lead, form a black sulphide when brought in contact with moist sulphuretted hydrogen or sulphide of soda or ammonia. Coal gas, even in the condition that it leaves the gasworks, generally contains traces of sulphur compounds. Most qualities of burning coal also contain sulphur, which is partly given off in sulphurous fumes on burning, which act on white lead; and there are other sources of sulphur-vapours, all of which injure painting containing white lead. Neither acids nor alkalies destroy the dark colour that white lead acquires by sulphur. Hence in this respect it is inferior to zinc whites, which are quite unaffected by sulphur fumes.

THE TECHNICAL POINTS CONNECTED WITH THE EMPLOYMENT OF FORM AND COLOUR IN INDUSTRIAL DECORATION.

CHAPTER III.

IN the preceding chapter the last paragraph was headed *"Colour in Decoration—Importance of the Subject."* To this we now direct our attention. Of all the gifts which a beneficent Creator has bestowed upon man, that of the appreciation of colour and delight in it is one of the greatest. While it is one of the simplest and most enjoyable, and which carries with it the purest of feeling, it is one also the most readily obtained, for it abounds everywhere,—in the tints of the sky, in the green of the fields, and in the thousand tints and tones of the flowers with which their surfaces are covered. And one point in what may be called study of colour is very noticeable, that the delight which the musician finds in the harmony of sound, the student will find exemplified in the pleasure derivable from the harmony of tints and tones in all masses of colour.

Definition of the Term "Colour."

By colour we mean harmonised pigments, or what are popularly called paints or colours. Now, the primary colours, yellow, red, and blue, we call "pigments," and only to their harmonised combination do we permit the term "colour" to be applied. The young student should take special note of this; for to any combination of pigments which do not harmonise, the term colour, in its true or artistic sense, is not at all —certainly not correctly—applicable, any more than it is correct to call sounds which do not harmonise music — the very spirit or essence of which is, so to say, harmony. Hence the student will perceive that, in the true technical, artistic sense, a pigment —or what is popularly called a paint, or still more inaccurately a colour—is only a constituent part of colour, not a colour itself—which, as above defined, is a "harmonised combination of pigments." We may illustrate this with some practical utility to the student, conveying, as it does, what is called a lesson, by the following incident. Two well-known men, high in position, were examining an object of art manufacture on which was depicted a certain subject: it was laid aside with the remark, "There is no colour in it." The salesman, so far from thinking it had no colour in it, was disposed to decide that there was quite too much of it. And in a sense he was right —that is, in the popular sense of the term colour. For the object displayed abundance of colour of one kind, the three objects constituting the design monopolising one of the three elementary colours or pigments, blue, yellow and red. Puzzled at this glaring evidence of colour enough being defined to be that which had "no colour in it," he asked an artist to explain the point. This was very soon done by giving what, in point of fact, we have already stated as the true principle deciding and defining true colour; for he said, "Colour in your sense of the term there is enough of, and more than enough, but it is made up of what we artists call pigments; in this object those pigments do not harmonise, therefore we say that it has no colour."

The Three "Primary Colours," or "Primaries" of the Chromatic Scale.

We shall now, in connection with the diagrams in the coloured plate entitled "The Chromatic Scale,' explain the technical terms used in connection with the application of colour in the artistic sense to ornamental outlines for flat surfaces; but of course what is true of decorative subjects is true of all subjects in which colour is employed. When white or ordinary light is passed though a prism, it is reduced, so to say, to its component parts. Those are found to be three in number, and give what is popularly called three colours—(1) yellow, (2) red, and (3) blue. These, therefore, are called primary or elementary colours. When artificial or natural substances are employed to imitate these colours or hues, they are called, as we have said, pigments or paints. There is no pigment made by man, or known to him, which gives those colours *precisely* as they are shown in the prismatic reduction of light. Hence artists employing colour have to select those pigments which give the nearest approach to the prismatic hue, which may be called the standard colour. The young student will perceive, as closely bearing on the subject, the inaccuracy of the popular expression a "shade" of colour, the expression hue or tint, sometimes tone, being more accurate.

The "Secondary" and "Tertiary" Colours, or the "Secondaries" and the "Tertiaries" of the Chromatic Scale.

The next scale to notice in the subject of colour is that connected with the "secondaries." By the term "secondary" is meant the combination of any two of the primary colours. Thus yellow and blue give (1) green, blue and red (2) purple, yellow and red (3) orange. These tints or hues, green, purple and orange, form the three "secondary" colours.

We now come to the third portion of the scale of colour, namely, the tertiaries—(1) citron, (2) russet, and (3) olive. They are called tertiaries because they are produced by the combination or admixture of two secondaries. Thus, by mixing green and orange we obtain (1) citron; by mixing purple and orange we get (2) russet; while a purple and green combination will give (3) olive.

The "Complementary Colours."—Definition of the Term.—Colours complementary to the Primary Colours.

We now take up the term "complementary" as applied to colour. By this is meant that the admixture of two *primary* colours is said to be the complementary colour to the remaining primary. Purple, for example, which is a combination of red and blue, is the complementary colour of yellow, the remaining or last of the primary colours. We are here presuming that the young reader is careful to remember that the primary, secondary and tertiary colours are, in all the three classes or departments of the "Chromatic Scale," made up of three in each, as shown in the Plate. Again, green, which, as a secondary, is a combination of yellow and blue, is the complementary colour of, or, simply stated, is complementary to red, which is the remaining primary. Orange, which is a combination of red and yellow, is complementary to blue, which is the third remaining primary. This simple rule for the guidance of the student should be carefully borne in mind: the colours making up the secondary leave but one primary, which is, of course, the complementary colour. Thus, in the above red and blue leave yellow, yellow and blue leave red, and lastly, red and yellow leave blue.

The Colours complementary to the Secondary Colours.

Having thus given the colours which are complementary to the primaries, red, yellow and blue, we now proceed to give the complementaries to the secondary colours, that is, what is the relation the tertiaries—citron, russet, and olive—bear to the secondaries, which are purple, green, and orange. Thus "citron," which is composed of green and orange, is complementary to purple; "russet," a combination of purple and orange, is complementary to green; while "olive," which is made up of purple and green, is complementary to orange. By this exhaustive process the student should be able to see the relationship which the colours in all the three classes, and in any one special class of the three, bear to each other.

Importance of attending to Tone of Colours.

He must be careful, however, as to the *tone* of his colours. By this we mean, if his citron, for example, tends too much in the direction of the yellow, which is one of its constituents, then his purple, which is the complementary, in the same proportion must tend towards blue, so that the two will harmonise, which they will not do if while one is in excess the other is deficient, or its excess be in the wrong direction. Whenever the colour is in excess, or tends too much to one, the complementary colour must be in proportionate excess. If this harmony be not maintained, then his colours, or subject, will be either too "warm" or too "cold" in tone.

"Warm" and "Cold" in Colour.—What is conveyed by these Terms.

What is meant by these terms is explained thus. We call yellow and red "warm" colours, and blue and green "cold." But there is this distinction in this cold colour, which the reader must bear in mind—as in the case of green, which he will remember is a combination of yellow and blue. If the yellow predominates, it is called a "warm green." Again, in the case of a purple, if the tone tends too much to the red we call it a "warm purple"; if it tends too much to the blue we say that it is a "cold purple."

Applying these principles to the student's design, if the colours on it tend as a whole towards warm colour, we pronounce it to be as "warm in tone," if too cold the converse. In applying this colour to his ornamental arrangements of lines commonly called, although not always correctly so, his design, the first counsel we should give the pupil is this—that he should begin with the colours in the tertiary scale, as he will find it easier to get a harmonious combination than if he adopted a higher scale—tertiary, as he will by this time understand, being the lowest of the scales of colour, primary being the highest, while midway between the two stands the secondary scale. If the pupil wishes to see what a beautiful effect may be had by the employment of a low tone of colour—that is, colour in a lower scale—let him examine, or rather study, any *good* (this qualification is necessary now-a-days, when rubbish is so plentiful) specimen of Japanese coloured ornament. We refer here to Japanese art, in which, as a rule, low tones are prevalent, and their artists, working always in the low scale, are, we do not hesitate to say, the finest colour ornamentists in the world. They in this matter afford a striking and most instructive contrast to their near neighbours the Chinese, whose practice in this respect is precisely the reverse.

The True Shades and Tones of Colour only found in Natural Objects.—Defects of Colour in Pigments made by Man.

We have prepared for the young pupil a sheet illustrating the scales of colour, arranged in complementary order,—that is, under the yellow the purple is placed, under the red the green, and under the blue the orange. These scales are, however, in fact, merely mechanical, being concerned with the practical work of admixture of pigments, for flat tones (for remarks on pigments, colours or paints, see "The Calico Printer" and also "The Colour Maker"). To get the true delicacy of colour we must refer the student to the combinations of colours as he finds them in nature. There only can he ever know what colour truly is. We shall have more to say of what this school teaches, and how its lessons may be learned. Meanwhile we would ask the pupil who may be doubtful as to the truth of our statement, to take up from the highway such a common object as a stone which may be lying there.

THE GEOMETRICAL DRAUGHTSMAN.

HIS WORK IN THE CONSTRUCTION OF THE FIGURES AND PROBLEMS OF PLANE GEOMETRY, USEFUL IN TECHNICAL WORK.

CHAPTER II.

In the last paragraph of preceding chapter we showed how a bent zigzag is a curved line returning into itself, a closed form, what is called a figure. What is enclosed within the lines thus joined is called a space, "the space enclosed within a figure," or what is sometimes, but more popularly, called a form, shape, or configuration. Or considering the space as bounded by the lines, we call that space a "surface" or "superficies." A figure may also be formed by a curved line or a curve, which, beginning at one point, is carried round till it again reaches the same point or returns into itself. Curved figures are regular and irregular. The regular curved figures are the circle or the ellipse. The remarks made as to the space and surface apply to the figures formed by curved lines. Geometry concerns itself with the construction of figures and with the estimation of their enclosed spaces or their superfices or surfaces. This latter forms the branch of mathematics known as the "Mensuration of Surfaces," as the corresponding branch of Solid Geometry is called the "Mensuration of Solids."

Curved Lines not Returning into themselves, or Open, forming what are known as the Regular Curves, as the Parabola, etc., etc.

There are certain classes of curved lines which are fixed and definite, and to which the name of the regular curves are given. They are said to be "open curves," as distinguished from those closed curves which, returning into themselves, give figures enclosing spaces or forming superficies: an open curve, however far the ends might be extended, would not meet.

Amongst the open curves there are some which start from a point and keep turning or extending in a curve *ad infinitum*: such is the Archimedean spiral. Others extend *ad infinitum* from the two ends: for example, the curve known under the name of the parabola. There may be said to be an infinite variety of curved figures and of curved lines,—they abound everywhere in nature; but it is with what may be called the regular or fixed figures and curves that geometry has to concern itself.

Convex or Rounded Lines.

The phrase a "convex line" or "convexity" is generally understood. There are but few who have not a perfectly clear idea of the words convexity or relief, or their opposite, concavity or hollow. Thus one will not hesitate to say that a hollow dish, looked at in the direction of its interior, turns its concavity towards the eye placed opposite it, and that the same dish looked at it from the outside turns its convexity towards the eye placed also opposite to it. From a consideration of these terms, we may see that this property is possessed by convex lines—namely, that they cannot be met by a straight line at more than two points.

Of the Plane.—Plane Surfaces, Figures or Configurations.

We now come to consider the term "plane." This is to the surfaces what the straight line is to lines in general. We have the idea of the plane, as we have that of the straight line. We generally define the plane by one of its properties, and we say the plane is a surface upon which a straight line may be applied in any direction. That, however, does not prove that such a surface exists in reality; but the idea of its existence is furnished to us naturally by the contemplation of exterior objects. It follows from this definition of the plane, and of the properties of the straight line—first, that a straight line cannot be partly in a plane and partly outside it; and, second, that a straight line which has two of its points in a plane is wholly contained in it. We content ourselves at present with these preliminary ideas of the plane. They are sufficient to enable us to divide into two great classes all the figures with which geometry concerns itself; those figures are, first, those which may be wholly included or enclosed in the same plane, which we term figures of surface or superficies, and which have but two dimensions, length and breadth; second, those which cannot be contained or enclosed in the same plane or figures with their dimensions.

Figures having length, breadth, and thickness we call solids. Geometry, then, is divisible into or may be treated of under two great heads—first, plane geometry or the geometry of superficies, or, to use the popular term, the delineation of certain figures or forms generally known as the geometrical figures; and, second, the problems connected with solid bodies, generally known as the geometrical solids. We shall, as already named, take up these two great divisions in the order here stated.

The first section of plane geometry, or that which concerns itself with the construction and the delineation of figures, is obviously that connected with straight lines. The peculiarities of the different classes or varieties of those and of the problems or constructions based upon and following them, we now propose to notice.

A Vertical Line.

A vertical line is that which is formed by what is called a "plumb line" or the line *a* of a "plummet," carrying a weight, as *b*, fig. 1, at one end of a cord or line, *a b*, held in the hand as at *c*, or suspended from a point as in the plummet of the mason (see "The Stone Mason").

All bodies left to themselves, that is, free to fall, and in a still atmosphere, fall in a vertical line, which, if sufficiently prolonged, would pass through the centre of the earth. Vertical lines in geometrical construction are drawn from top, *d*, to the bottom, *e*, of the sheet of paper. If a drawing board is used, the head or cross of the T-square is placed on the upper or under edge, *d g* or *e h*, of the board; and all lines drawn along either edge of the blade will be vertical. (For description of drawing appliances see the paper entitled "The Building and Machine Draughtsman.")

Vertical lines, therefore, are those which incline neither to the right hand nor to the left; but, to use a popular phrase, stand "straight up" or hang "straight down."

Distinction between a Vertical and a Perpendicular Line.

The young geometrical draughtsman must be careful not to conclude that a "vertical" line and a "perpendicular" line are identical, meaning precisely the same thing. From what we have said, a "vertical" line must always be perpendicular to the line of the horizon, or what is popularly called the surface of the earth. But a line which is perpendicular may not be vertical at all; in point of fact, it may be absolutely horizontal in itself in relation to the line with which it is connected or compared. This will be evident to the student when he understands the definition of a perpendicular line. It is a line which is so related to or connected with another line that it forms with it a right angle (see succeeding paragraphs on "angles"). Thus in fig. 1 the line *j k* is at right angles to the line *l m*, the angles *l k j*, *m k j* both being right angles. Here the line *j k* is vertical because the line *l m* is horizontal—that is, parallel to the horizon. But although the conditions in regard to the relation of the two lines to each other are the same, in the diagrams *n o*, *p q*, *r s*, *t u*,—*n o*, *r s*, corresponding to *k*, and *p q*, *t u*, to *l m*, and the angles *n o p*, *n o q*, *t r s*, *u r s*, are still right angles, no one would say that either the line *n o*, or *r s*, was vertical,—the latter, indeed, is horizontal. We have been thus particular in drawing the attention of the pupil beginning the study of geometrical drawing to the distinction between a vertical line and a perpendicular one, as so many mistakes are made with regard to it by young students. A perpendicular line may assume any position by itself between the vertical and the horizontal.

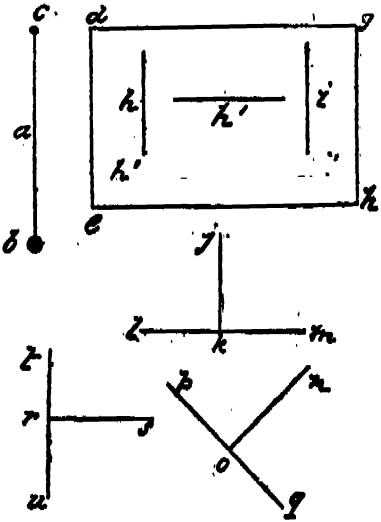


Fig. 1.

A Horizontal Line.

This leads us to define what a horizontal line is. It is so called from its being in the same position or parallel to (see further on for definition of this term) the line of the "horizon" of the globe or earth.

A horizontal line is popularly illustrated or represented by the surface of water in a state of absolute repose, such as the water of a pond, of a lake, or of a canal, taken across its surface width. A horizontal line is also called the line of level, or of general level, illustrated in fig. 2; in this, which is a sectional sketch of the side walls of a house, *a b* is the level of the floor excavation, *c d* that of the ground outside. Horizontal lines, contrary to vertical lines, are drawn across the width of the paper, as *h'* or *i'* in fig. 1. If the drawing board be used, the head or cross of the T-square rests on one of the lateral edges of the board, generally placed along the left-hand edge, as *d e*. The left hand may rest on the sheet, and follow, to a certain extent, the movement of the right hand when the latter is drawing a line, so that the pressure of the blade of the T-square may be equal throughout. But expert draughtsmen generally keep the left hand on the head, so as to ensure its being against the edge of the board; the right hand, in tracing or drawing the line, pencil or inked, keeping at the same time the blade close to the surface of the paper by sliding the little finger, or two last digits, along its surface.

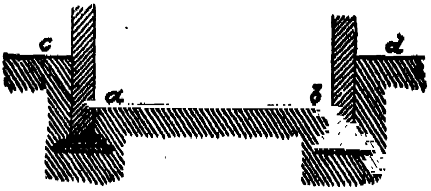


Fig. 2.

THE YOUNG ARCHITECT OR ENGINEER.

HIS STUDIES—OFFICE DUTIES—AND PRACTICAL WORK IN THE PREPARATION OF WORKING DRAWINGS, OF SPECIFICATIONS, AND CONTRACTS FOR WORK.

CHAPTER V.

What constitutes a "Full Set" of Drawings decided by different Practitioners.

THE preceding paragraphs were chiefly taken up with detailed statements as to the drawings required to be made for buildings proposed to be erected, their various classes or varieties, and their leading characteristics. Numerous as these classes or varieties of drawings are, the pupil need scarcely be informed that in practice very considerable modifications are made on the system which demands that the "full set" should be provided by the architect. Many buildings, even those which cost a considerable sum, are erected, for which a much less comprehensive series of drawings is provided than those we have named. Builders who act as their own architects content themselves with the minimum number of drawings, these comprising, for the most part, a plan of each of the floors, as basement, ground, and chamber plan, an elevation, and possibly, but not always, two sections, one longitudinal, the other cross or transverse. (See the paper entitled "The Building and Machine Draughtsman" for explanation of the different terms used in connection with drawings.) Often but one section is provided, and that taken in a line requiring the least amount of drawing, and the object of which is simply to show the heights of the different floors or stories. And not seldom is it the case that no section at all is provided, the heights being taken from the elevation only. So lightly do some builders think of drawings, that there are those who go to work in erecting a house with nothing more than the plan; if any elevation at all be provided, it is little more than a sketch, generally done in pencil, as are indeed, often enough, the plans also.

Carelessness as to having a really Full or Complete Set of Drawings, much to be condemned.

It need scarcely be said that this carelessness as to providing a sufficiently large number of drawings is most reprehensible. Still more so the practice which, as just hinted at, is that of some builders, which permits them to be indifferent as to whether the drawings are inked in or pencilled in—which last method of procedure obviously admits of any unscrupulous person obliterating from the drawings some point or part which may involve legal liabilities. If a thing is worth doing at all it is surely worthy of being done as well as it can be. And, however small the number of drawings a builder may rest satisfied with, he should determine that those shall be carefully done, so as to admit of no possibility of error arising in after construction. Where he is building for himself he may conclude that this care is not necessary: nay, he may pride himself—as we have known of those who could so pride themselves—upon his ability to build a house without the aid of any, or at least, with that only of the very fewest number of drawings.

Complete Set of Drawings demanded in the Interests of the Clients or Employers of the Architect.

But when he is building for another, the true interests of his client or customer demand that he should give to that client all the advantages which flow from a complete set of drawings most carefully prepared, and accompanied by a complete—not the mere sketch of a—specification. If he will not remember, the client in his own interests should, that those drawings and that specification constitute, as it were, the legal documents which record and prove the bargain made between the builder, who is to construct, and himself, who is to pay for the house which he is desirous to obtain. Their full importance in this respect, as well as in the legal responsibilities which the specification by itself carries or conveys, and taken also as along with and forming part of the drawings—the two together forming the recorded bargain between the two parties—will be fully detailed in a future chapter.

Illustrations of a "Minimum Set" of Drawings for a Domestic Structure.

Meanwhile, we proceed to explain in a general way what drawings are required as a minimum for a house which, although not very costly, still involves in building the expenditure of a goodly number of hundred pounds. In buildings of a less costly kind, such as a cottage costing a hundred or a hundred and twenty or fifty pounds; or even a small dwelling-house costing but two or two hundred and fifty or three hundred pounds, a less numerous set of drawings, as those we are now about to give, may suffice. But every one about to build, and calling in, if he be wise in his own interests, the aid of a competent architect or builder, should bear in mind what is a corollary from what we have stated—that his interest will lie more in the direction of having too many, than in that of having too few drawings. The more he has of these, and the more fully detailed is the accompanying specification, the more likely is the house to be finished with the minimum of mistakes either in arrangement or in construction. And if these are unfortunately made, he will be able to have his legal remedy—if he choose to avail himself of it—for such, inasmuch as reference can be made to the drawings and specifications in proof that those mistakes arose either from wilful or careless neglect of their provisions.

The following are the drawings referred to, as constituting what may be called a "minimum set" for a house of some pretensions as to completeness in arrangement for a family occupying what is called "a good position in society," giving ample accommodation for a family of some number, or for several visitors and retainers; and also having some pretensions to architectural design. In figs. 1, 2, 3 and 4 we give the various "plans," in figs. 5, 6, 7, and 8 the "elevations," and in figs. 9 and 10 the "sections." In a building of this size various details to large scale and to full size will be required of the principal parts of the external decoration, such as the mouldings of the entrance door in the front elevation, fig. 5; the string-course, base mouldings, and of chimneys, and details of internal work, such as cornices, architraves, etc., etc.

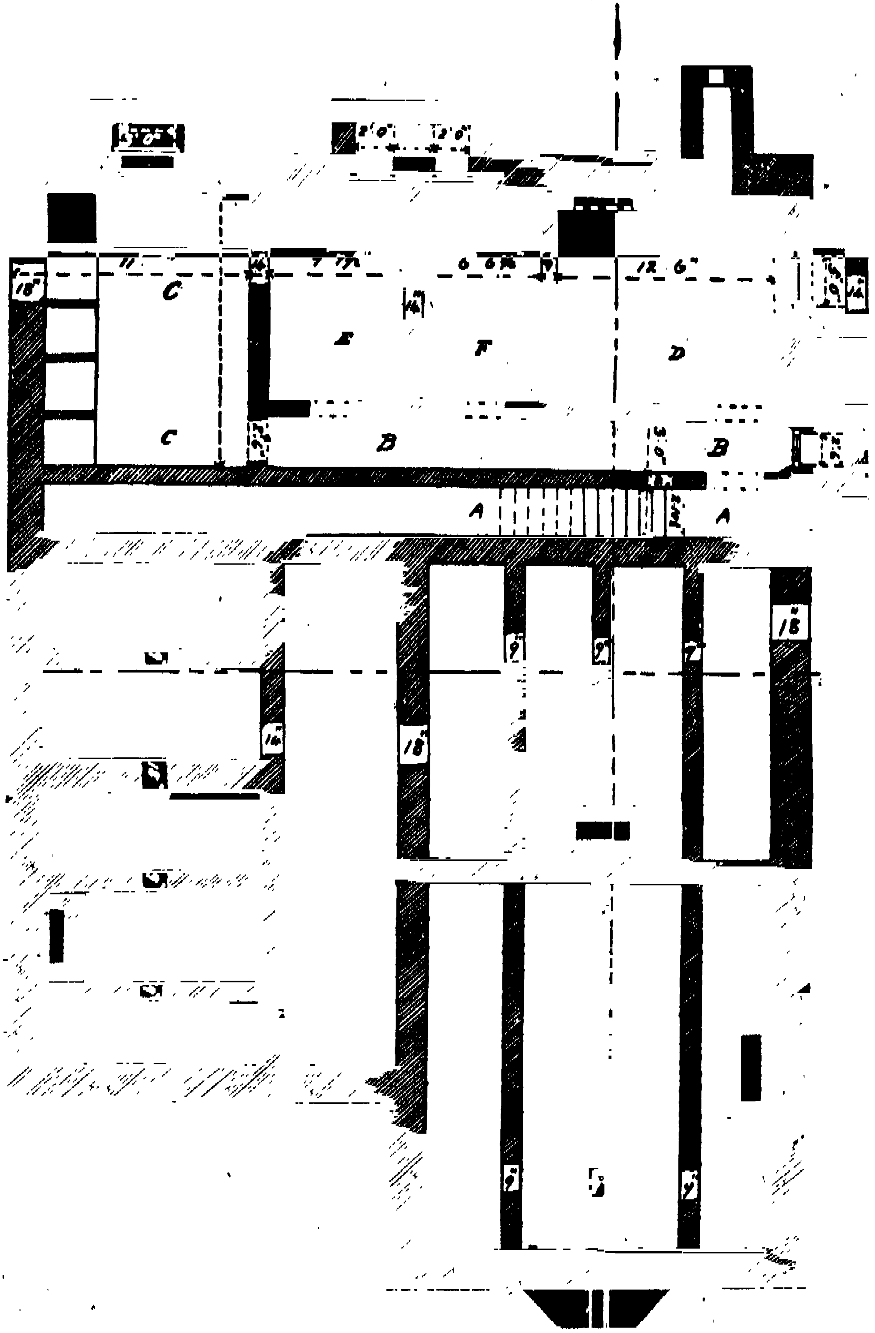


Fig. 1.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

62. The Working Condition of Belts.

IN our last note, under the head of "The Condition of Pulley Surfaces," we took into brief consideration some points connected with the slipping of belts on the pulley failing to grip it, or of pulleys within belts failing to grip them. And this led us to notice the methods—or some of them—in use to prevent this slipping, those being applied to the belts. We also explained the method of dealing with the slip of belts by the converse method of treating the surface of the pulley itself in a certain way. Taking the first named of these two methods of dealing with slip, the reader will perceive that the plans adopted must exercise an influence upon the condition of the belt itself according to the substance used to increase its grip upon the pulley or the converse. And one or two at least of the substances used we showed have a deleterious influence upon the belt. It is obvious that the condition in which the leather of a belt is at the time of working must have a marked influence of one kind or another on the results of power transmitted by it. A belt, the leather of which is hard and unyielding, cannot when wrapped or rather bent round the part of the circumference or rim of the pulley embraced by it, take readily and easily the curve of the pulley, but will fail to give the grip to, or conveniently to receive the grip of, the pulley. This is considered in relation to the length of the belt and the periphery or curve of the pulley rim; the probability being that the belt will bag or belly up so that at parts it will not touch, or scarcely touch, the pulley surface. But if we consider a belt in this hard and rigid condition in relation to its width—that is, transversely to the face of the pulley—it will be observed that its very rigidity will tend to keep it from gripping the surface at all points across its width. And if the pulley have a decided or a greater convexity than should be given to it, the tendency of this hard rigid belt will be to ride, so to say, on the top only of the swell or the longest diameter of the pulley, from sheer inability to bend itself at the sides downwards, so as to embrace or come in contact with the sides of the swell or transversely curved part of the pulley face. If the belt leather, however, be limp or soft and yielding, it will be seen that its relation to the surface of the pulley will be very different from what has just been stated. We have a very familiar illustration of what may be called the "wrapping" value of leather in a leather glove—a kid glove—of good quality. When new the leather is so soft and limp and thoroughly pliable that it "wraps" round the hand, or its fingers "grip" them, to use the technical term, so closely that with a well-fitting glove, the surface, as across the back of the hand, will be smooth and equally stretched. But the very same glove, after some time of wear, by the perspiration of the hand, or through getting wet, or one or other or more of many causes, will get hard and unyielding, and in place of lying close to and wrapping the hand or the fingers round, will bag up here and there, and get so altogether unsightly, that the man of fashion, to avoid this condition, discards the gloves long before they reach, or in conscious anticipation of the time when they would reach, this unaccommodating condition. How to get belts and keep them in the condition in which, limp, soft and lithe, they will "wrap" closely round and firmly grip the pulleys or be gripped by them, is a point of some importance. In the treatment of belts to arrive at this as their normal condition, a considerable diversity of opinion and of practice is found to exist. While some subject their belts to a periodical oiling, and some to a careful "stuffing," as they call it, of a somewhat elaborate composition of greasy stuff, others roundly assert, in condemning the application of even a moderate modicum of oil, that in proportion as belts are oiled so is their slip increased. Others maintain that oils not only cause slip, but injure the fibres of the leather, weakening the belt considerably. Much of divergence—in some cases the direct contrary—of opinion on this point would probably be got rid of if we knew all the conditions of the varied practice. The quality and character of the oil used has a very considerable influence; vegetable oils are, for example, much more likely to be injurious to the leather than mineral oils, from the comparative ease with which they set up acid actions; and these can scarcely be established without injuring or tending to injure the fibres. And as regards the tendency which, according to some, oil or grease has to cause slip, we should also require to know the conditions of working in both the unoiled and the oiled belts. It is just possible that where trials have shown slip to exist, the other advantages of having the leather so pliable as to grip the pulley surface have been overlooked. Belts do become hard and dry through working, and a hard belt, as we have shown, cannot grip a pulley like a soft and pliable one. Yet the belt may be dry, while by no means unpliable; in this case a practical user of belts on the large scale states it to be his practice to apply melted tallow at a temperature of between 70° and 80°, this being rubbed well into the belt and dried in the sun or before a low fire. The oil of the tallow soaks into and softens the fibres, while the stearine or waxy matter remains outside and makes a smooth surface. When the belts are both hard and dry, pliability is restored by the method adopted by the same practician of applying neat's-foot oil mixed with a little resin, which last substance, according to him, prevents the oil from injuring the fibres, and tends to preserve them. Others, however, assert that resin in any form is prejudicial to belts. When used in its pounded or powdered condition it does after a time exercise a bad effect upon the transmitting power of the belt, though as we saw in a paragraph preceding this, it is used expressly to increase the grip. Other practicians use and strongly recommend dubbin or tanners' dubbin, or "dubbing," as by far the best dressing for belts, and being taken, to apply it only to the flush side. We certainly know how good dubbin is for softening leather and making it limp and pliable. Belts treated as above with it are said to have lasted six times as long a period as those which have not received a dressing of the dubbin. As our space is for the present exhausted, we shall shortly return to it, as there is much on this and other points connected with belts yet to be glanced at.

63. Bessemer Steel Castings.

In a preceding note (No. 28, p. 185) we gave a description of the principle involved in the process of producing sound castings of Bessemer steel, and referred therein to the important part mechanical mixture or agitating of the molten mass played in the process. After noting other points of this highly important technical question, we shall give a brief description of the "mechanical agitator," which has already done much, and promises—at least, the principle which it involves—to do more, in getting rid of a difficulty in connection with Bessemer steel. And this difficulty has admittedly, even by its most earnest advocates, had a very marked influence in keeping Bessemer steel from being used for making a wide variety of mechanical objects and implements for which the best wrought iron and fine crucible steel have been and are now largely used. If Bessemer steel can be used to compete with those old-established metals, its well-known and valuable qualities will have another element in their favour which will give to the manufacture, characterised as it is by all the features of a rapid and economical production, a still wider range of usefulness, and create for it a still greater demand than it has yet met with, great as both have been. What is the present position of the manufacture, and whether this more extended use of its product is or is not likely to become a practical everyday business fact, the reader will be able to form some opinion upon after reading what in this "note" and other "notes" is yet to be given on the important question. Meanwhile we have at present only to remind the reader that this wider range of utility for Bessemer steel is claimed for it by thoroughly practical men, on the ground that the principle we briefly explained in Note No. 28, p. 185, has been proved as eminently successful in practice. In the note just referred to we pointed out that the agents or substances used to quieten or soothe down the seething mass which Bessemer steel presents in the ladle into which it has been poured from the "converter" in which the cast iron has been converted, into steel, are in themselves, if in excess, impurities or substances which deteriorate the quality of the steel. Long experience, aided by the closest of observation, enable these substances to be used with a degree of accuracy of adjustment to the requirements of the steel, which it is desired to make of a certain standard approaching closely to practical perfection. And the problem has been rendered all the easier of solution by the fact that of the various substances at one time used as quieting agents one is now chiefly used—namely, ferro-manganese. This, at one time not available, except in comparatively small weights, was by improved processes, largely consequent upon the highly successful practice of a well-known Continental steel-making company, showing the great value of the ferro-manganese, rendered available in large bulks. Those of our readers who are acquainted with the process of Bessemer steel making know the important part spiegeleisen plays in it; those who are aware of the peculiarities of the manufacture will find a notice of this material and its action in steel making in the series of papers in this Journal entitled "The Steel Maker." In converting cast iron into steel by the Bessemer converter process, the object is not merely that each charge shall possess a certain amount or percentage of carbon, but also that the materials, such as spiegeleisen and ferro-manganese, which it is found in practice necessary to add to the charge at the conclusion of the process, and before the charge, as a whole, is turned into the ladle, shall be thoroughly mixed with the iron converted into steel by the peculiar action of the "Bessemer blow." When we consider that the peculiar characteristic required in the metal of a given charge or blow, such as hardness, depends upon the quantity of those added materials, the young reader will perceive how essential it is that each part of the mass shall receive the percentage or amount of these materials due to it, so that the mass throughout shall be of equal character or homogeneous. We see the necessity for this uniformity of character in the steel, whatever be the proportions of the added substances used to gain a certain quality in the steel; and we find that those proportions vary very materially. Thus in a five-ton charge of converted steel, when a certain degree of hardness is required to be given to it as much as from 14 to 15 cwt. of spiegeleisen is added; while another charge to have a certain quality of softness will have as low a weight as 84 lb. of ferro-manganese only added to it. In the one case it is obvious that the mixture of the large mass of spiegeleisen must be very complete, as from the very largeness of the added bulk of material, if mixing be not complete, some part may have an extremely heavy overcharge of the hardening material, while another part may have just as great an undercharge. Nor is the necessity for thorough mixing of the constituents less urgent in the other case, where the bulk of added ferro-manganese is very small; for in this case, if admixture be not thorough, it is obvious that while some part may have just the right proportion due to it, another may have too little, while another part may have none at all. And when we trace such charges of imperfectly mixed materials in the after processes of the manufacture through which the metal is taken, we can easily understand how a rolled bar or rail may have some part of its length of a different quality or constitution from another, being too hard or too soft, as the case may be, or of greater or less strength; and therefore how untrustworthy it may be as a mass or whole for constructive purposes. And when we consider further how exceedingly minute in one sense is the difference between one piece of metal in regard to one constituent—phosphorus, and another, the small excess of this constituent in the one making an unsound or untrustworthy rail or bar, the other having a less or right percentage of phosphorus being thoroughly sound and trustworthy, we are still more convinced of the necessity which exists for the whole of the constituents of the Bessemer steel charge being thoroughly mixed and blended together. But another point remains to be noticed, although it was more or less incidentally referred to in Note No. 28, p. 185. This is, that the addition of the substances we have named as necessary to the perfecting of the iron converted into steel is, in itself, one of the causes of the mixed metals having that frothy, seething, "blown" condition which constitutes one of the grave defects of the charge when it is turned from the converter. The two metals are in point of fact so dissimilar—namely, the decarbonised iron charged with oxygen, which forms what may be called the primary element of the converter charge, and the metal of the highly carburetted spiegeleisen or the ferro-manganese—that when mixed or thrown together a violent ebullition takes place causing large disarrangement of gases, to which in the previous "note" we alluded, and which bubbling up and escaping of gases continues till a more or less perfect admixture of the whole be secured. We have thus a reason of doubled urgency for getting this perfect mixture; first the necessity to mix the added constituents or materials which are given to produce a certain quality, so that all parts of the mass shall possess as precisely similar a quality as it is possible to obtain; and secondly, that by thorough mixing the gases, in place of being occluded, or, as we should say, closed in the mass, shall be allowed to escape, and thus prevent the formation of the honeycombed or blowholes which, as we have seen, have formed and still form so undesirable a peculiarity of many Bessemer steel ingots. While some of our readers will now admit the necessity of this thorough admixture of the constituents of Bessemer steel, in order to ensure sound and solid castings, they may be disposed to conclude that, being in effect a chemical mixture of certain chemical constituents, this will be complete. But it is only an imperfect or comparatively incomplete acquaintance with chemistry which can give rise to this opinion. For, as has been well pointed out by the late Sir William Siemens, who was as eminent for his chemical knowledge as for his mechanical ability—both being of the highest order—there is "such a thing as imperfect and perfect chemical admixture." And he illustrated it in his usual happy way by taking the very familiar example of soda in effervescing water. You might pump, as he said, "carbonic acid gas into water and make soda water," but if it were used immediately after it was made you "might just as well save yourself the trouble of forcing the carbonic acid into the water, because it came out instantly." But if a second bottle of the mixture were made and kept closely corked up for a week, so good a chemical combination or admixture of the gas and the water would be obtained that the liquid would have some claim to be called an effervescing drink in which both gas and water would be swallowed—the gas not flying off so quickly but what some would be retained. But if a third bottle were made, and this kept up closely for three months, so complete would be the combination of the gas and water—admixture with or absorption of the gas by the water—that the liquid might be poured out into a glass and left open, and yet gas would be retained by the water for a considerable length of time. It is just possible, and we are inclined to believe it to be very probable, that as the result of the close and continued study, combined with a never-tiring carrying out of experiments, both on the large or furnace or workshop, and the small or laboratory scale, some method will yet be discovered by which the chemical admixture of the constituents used in the making of Bessemer steel will be as rapid as it will be complete, obviating all necessity for a mechanical admixture. Meanwhile this seems necessary; and although there are some thoroughly able and practical men who maintain that this lack of soundness in Bessemer steel ingots does not arise from the want of a thorough mechanical admixture, but from causes other than and probably in addition to this, the system of mechanical mixing as introduced by Mr. Allen, of Sheffield, has proved itself to be of the highest practical value. It is right to state that, with that remarkable characteristic of Sir Henry Bessemer of looking at a subject so thoroughly all round, he is able to foresee or anticipate coming difficulties, and to be able to provide for them. This able and successful metallurgist long ago patented a method of securing a thorough admixture of the constituents of his steel. Sir Henry thus proposed, and indeed devised, a mechanical agitator revolving in the fluid metal; this being covered with melted slag, so that the atmosphere was prevented from coming in contact with the metal as it was stirred. We have so completely exhausted, or more correctly stated have so exceeded, the space allotted for this "note," that we after all cannot redeem our promise at present to describe Mr. Allen's apparatus. This, however, is the less to be regretted—if, indeed, there be cause for any regret at all—inasmuch as what we have given is so important to be understood by the youthful or inexperienced reader, that the description of the apparatus may well be deferred to the space of another note; and this we hope to give in our next number.

64. The Weight of Iron per Square Foot in Ounces of Different Thicknesses as per "Nos." of the Standard Wire and Metal Gauge

In a future note the thicknesses in parts of an inch corresponding to the "Nos." of the gauge here given will be found.

"No." of Gauge.	Weight in ounces per square foot.	"No." of Gauge.	Weight in ounces per square foot.
1	192·00	16	40·96
2	176·64	17	35·84
3	161·28	18	30·72
4	148·48	19	25·60
5	135·68	20	23·04
6	122·88	21	20·48
7	112·64	22	17·92
8	102·40	23	15·36
9	92·16	24	14·08
10	81·92	25	12·80
11	74·24	26	11·52
12	66·56	27	10·49
13	58·88	28	9·47
14	51·20	29	8·70
15	46·08	30	7·93

65. Weight in Pounds of Square Bars of Wrought Iron per foot lineal, from a quarter of an inch on the side up to two inches.

¼ inch = ·208 of a pound; ⅜" = ·468; ½" = ·833; ⅝" = 1·3 lb.; ¾" = 1·87; ⅞" = 2·55; 1 inch = 3·33; 1⅛" = 4·21; 1¼" = 5·2; 1⅜" = 6·3; 1½ = 7·5; 1⅝" = 8·8; 1¾" = 10·2; 1⅞" = 11·71; and 2 inches = 13·3 lb.

66. Weight in Pounds of Round or Rod Wrought Iron per lineal foot of diameter from 2⅛ up to 5 inches.

2⅛ inch diameter = 11·82 lb.; 2¼" = 13·25 lb.; 2⅜" = 14·76; 2½" = 16·36; 2⅝" = 18·03; 2¾" = 19·79; 2⅞" = 21·63; 3 inches = 23·56 lb.; 3⅛" = 25·56; 3¼" = 27·65; 3⅜" = 39·82; 3½" = 32·07; 3⅝" = 34·4; 3¾" = 36·81; 3⅞" = 39·31; 4 inches = 41·88 lb.; 4⅛" = 44·54; 4¼" = 47·28; 4⅜" = 50·11; 4½" = 53·01; 4⅝" = 50·00; 4¾" = 59·06; 4⅞" = 62·21; 5 inches = 65·45 lb.

67. The New Waterproof or "Willesden" Paper for Roofing Purposes.

A new method of preparing paper and other substances, as textile fabrics, so as to resist damp, mildew, etc., and which gives them other useful properties, has been recently introduced, and details of the process so perfected that it is being now carried out on the commercial scale at Willesden, near London. The process affords another example of the service done by the theoretical chemist to the practical work of the day, and in adding new industries to the infinitely wide range already existing. This paper can be used for a variety of purposes, and amongst others for the covering of roofs of sheds, etc., for which purpose it promises to be a decided rival to corrugated iron and zinc, as being not only much lighter, but cheaper. And, if the commercial samples come up to the value of the experimental ones, it will, we think, quite cut out the use of roofing felts, to which there are so many objections. The peculiar chemical features of the process may possibly form the subject of a succeeding note under this section; meanwhile under this head it will suffice to state this much: that the paper and other fibrous substances, such as canvas, to which it is specially applicable, are treated with a chemical compound to which the name of "cupra-ammonium" has been given. This by chemists is generally considered as indicating one of that class of substances which is obtained by a combination of ammonia with certain compounds of copper, the result of which is a "metallo-ammonium" containing copper. All those compounds have been long known to have the power to dissolve the cellulose with other allied or similar substances present in paper, cotton, and other vegetable tissues, or if not of dissolving them, so acting, as in the opinion of some chemists they only act, in gelatinising the cellulose and allied substances, or disseminating them just as starch is spread in water. Be this as it may, the action may be taken as one of dissolving, and the cellulose forms a species of glue, gum, or cement, which gives to the paper or other tissue under certain treatment properties which enable them to resist damp—becoming waterproof, and from the presence of copper in the substances preventing the attacks of insects, mildew, rot, etc. The best results in those directions are obtained by the use of the metallo-ammonium compound known as the "cupra-ammonium hydroxide," another great advantage possessed by which, as compared with the cupra-ammonium sulphate, another of the compounds, is that no copper is precipitated, so that the iron tanks and iron and steel mechanical appliances used in the manufacturing process are not subjected to injurious attacks of this kind—care only having to be taken that no copper or brass is used in those appliances, otherwise corrosion is unavoidable. The solution of the cellulose in the paper, etc., not only covers it with a species of cement, but seems to bind or weld together the filaments of the fibres. This property is taken advantage of in the manufacture of the peculiar paper described as "Willesden welded," which is proposed to be used as a substitute for galvanised iron, zinc, or felt, for roofing purposes. The other class of paper made under the process is termed the "Willesden unwelded," and is simply a single web or ply of paper passed through a bath of the solution and rolled and dried. This covered with the cement-like substance—cupra-cellulose—previously named, gives it damp-resisting properties, which amongst other uses makes it specially useful for covering *damp walls* of buildings, or preventing them from becoming damp. The "welded" paper consists of two or more plies or sheets of paper, superposed, passed through the bath of the cupra-ammonium hydroxide solution and rolled so as to form a close, solid sheet or homogeneous "panel" of continuous and indefinite length, of a given width. It is this cupra-papyrus material, as we may call it, which is the roofing substance, and which being sent out from the factory as rolls, can be transported easily from place to place, and is also in the best form for working. This roofing panel, or paper board, is made with four plies or single sheets of paper. Comparing it with galvanised iron, a "square," as it is technically termed (*i.e.* a hundred square feet), of the paper weighs only 15 to 18 lb., the galvanised iron 103 to 280 lb. Taking another mode of estimating the relative values, it is found that a ton weight of the paper will cover 12 to 15,000 square feet, or say from 120 to 150 "squares"; the galvanised iron, on the other hand, will cover only from 800 to 2170 square feet, or say from 8 to 22 squares. The very great difference in the cost of the two materials is abundantly evident; the saving in mere transport, as in the case of colonial buildings, for example, being large in amount. The question of mere relative cost is, however, regulated or made valuable only if the constructive qualities of the paper are at the best not less valuable than the galvanised iron. We believe that it will compete favourably in its constructive features with the best galvanised iron. In the first place, the paper being so very much lighter than the galvanised iron, much lighter timber work for the roof truss will be required. And as there is a much less cubical quantity of timber there is a corresponding lessening of the risk of and loss from fire. Again, on the other hand, while the paper is not absolutely incombustible, like the galvanised iron, it is practically fire-resisting, not merely on account of its metallic nature, but from the density of the material itself. This feature is often lost sight of, yet it is a valuable one: it is not, for example, so easy a matter to set fire to and consume completely a sheet of thickish cardboard laid flat on a surface. In the second place, a building covered with a paper roof will have its interior temperature much more uniformly maintained than one covered with galvanised iron. In tropical climates, and even in some seasons in this climate, the heat under a galvanised iron roof is at times almost intolerable, while at night the "drip" arising from the rapid condensation of vapour is in itself a great inconvenience in most buildings. We may look forward with some degree of confidence to this new material being applied to a wide variety of constructive purposes. It seems to us well adapted for many simple forms of buildings, such as sheds, farm buildings, etc., and we feel assured that cottages constructed with it would be infinitely more comfortable and healthy than the great majority of originally ill-built and now tumbledown brick cottages, which are neither wind nor water proof in wall or roof.

68. Building or Garden Plots of Land—Breadth or Width of Plots of a given Length required to make a Statute Acre in Superficial Measurement. (See Note No. 24 for Plots from 3 yards up to 89 yards odd in length.)

Width of Plot.			Length of Plot.
Yards.	Feet.	Inches.	Feet
86	1	4	168
83	1	5	174
80	2	0	180
78	0	2	186
75	1	11	192
73	1	0	198
71	0	7	204
69	0	5	210
67	0	8	216
65	1	3	222
63	2	1	228
63	0	2	234
60	1	6	240
59	0	1	246
57	1	11	252
56	0	11	258
55	0	0	264
53	2	4	270
52	1	10	276
51	1	6	282
51	1	3	288
49	1	2	294
48	1	3	300

THE PRACTICAL NOTE-BOOK
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INDUSTRIAL SCIENCE FOR HOME STUDY.

(22) In our last Note (No. 18), on the subject of "raising of steam," we explained how the heat of a fire in boiling water resulted in mechanical force, as manifested in certain actions. In forming a theory of boiling we may best judge of its accuracy or otherwise by the way it "squares with" or coincides and is supported by facts of actual work, so far as we know them in practice. The following theory or explanation of what takes place in boiling is accepted by those who have practically studied the subject, as it squares well with the indications of that practice. We have seen in the simple experiment named in last Note (No. 18) how a circular motion is given to the mass of water by the action of heat. A circular or gyratory motion of the like character is by the action of heat given to each molecule or particle of water, which thus keeps whirling round its own centre. These molecules are attracted to each other, and form little groups or larger particles or bodies, which still keep up the whirling or gyratory motion. And as this motion is caused or created by the heat, the greater the number of increments of the heat which the water particles take up—thus getting hotter and hotter—the more the whirling speed is increased. And this keeps increasing as more increments of heat are taken up; until the velocity at last acquired is such as to overcome the force of attraction which keeps the particles of the water together. A separation or flying apart from each other then takes place, and the liquid or fluid condition of the water is changed to the vaporous or gaseous form, and steam is produced, which, when the boiling is free and not effected under certain constraints, hereafter to be described, passes instantly upwards through the mass of water, and escapes readily from the surface in the form of a vapour, which is called "steam." The motion of the watery particles, wholly the result of the heat taken up by them, is always circular or gyratory, and is always of this kind of motion at all temperatures below that at which the flying apart from each other or the separation of the watery particles takes place, and they are changed into vapour; and this circular motion of the watery particles is termed the "thermal" or "heat motion" of the water. But at all temperatures above the point just named (to which the name of the steam-flashing point may be given) the combined vapoury and watery particles—for till the vapour actually gets free from the mass of water this combination exists—have their motion changed from circular to lateral or longitudinal. With this, as they dart from one part of the mass to the other, they strike against the sides of the vessel in which the water is being boiled with greater or less force. And although this force for each particle of combined vapour and water, or watery or "primed" vapour, is infinitesimally small, still they are so innumerable in a large mass of water, such as a steam-engine boiler contains, that the united force is great—so great that they cause shocks or bumps against the boiler plates which are quite audible, as any one who knows what "boiler tenting" is well knows. And they can be felt also by resting the hand upon the boiler sides or top, when the vibration will be more or less noticeable. These combined particles of water and vapour, thus striking laterally against the sides of the vessel, recoil or rebound from them, and others coming up to supply their place, a continuous volley, so to call it, of shocks or blows is kept up, so long as the temperature is high enough and maintained. The result of this action is a condition of the watery vapour in which it may be said to be the vehicle of a force, and to this is given the technical name of pressure. As we have seen that the primary manifestation of force in water which is being boiled is circular, and is termed "thermal" or "heat motion," so the secondary manifestation of force, in a lateral or longitudinal direction, is called "pressure motion." And how true it is that the heat produced by the combustion of fuel in the furnace of a steam-engine boiler is neither more nor less than mechanical force, is proved by the fact that the heat which is required to produce a pound weight of steam is more than equivalent to half a million of "foot-pounds." The marvel is that, although all the phenomena of heat as applied to work—this specially of steam raising—had been known for long, and must have struck more or less forcibly many able practical men and scientists, no one till that eminent scientist Dr. Joule, of Manchester—who has lately been taken away from amongst us—took the matter up, and discovered and expounded clearly the law establishing the "mechanical equivalent of heat." But it is ever the province of true genius to see in what are called the "common things" of life some principle or law which gives grand dignity to that which others thought and talked about as mean and of no account. The vapour which passes off from boiling water in the form of steam is not passed off quickly; on the

contrary, inclosed as it were between the molecules of heated water, it is retained—sometimes through bad arrangements detained—in the mass of water for a longer or a shorter period according to the condition of boiling. What is called steam is generally only a mixture of steam and water; often, indeed, the latter is present in large proportion, giving rise to the evil called "priming,"—a source of inconvenience and loss in the working of the steam-engine, finding entrance as the mixture does to the cylinder. This water is the result of violent ebullition, or what may be called defective boiling; for if that were carried on easily and without constraint, the vapour would escape from the mass of water so easily that comparatively little water would be mixed mechanically with it. No doubt but little more comparatively is known of the "behaviour" of water when boiling in the water space of a steam-engine boiler, than is known of the behaviour of steam in the cylinder of the engine. If we could see into the inside of both when working, we should then see what the difficulties are which so puzzle engineers. But we know sufficiently now of what boiling is to justify the belief that before long we shall witness a great change in the arrangement of evaporating vessels of all kinds. If this should cause the statement, on the part of some, that from the very number of forms of steam-engine boilers, for example, we must have made such vast improvements that no great further change need be looked for—is not, indeed, required—this may be replied:—All the forms cannot be equally good; each new form, indeed, ushered into the market claims to be a great improvement upon those which have preceded it and are in use, and the statement is not seldom made that the new form is destined to render all other forms obsolete and quite out of date. The very number of new forms introduced, and in quick succession moreover, is in itself evidence that each new competitor is endeavouring to solve a problem the conditions of which have not yet been met.

(23) Under the head of "Cements" (see Note No. 21) we give now, one on the celebrated Armenian —sometimes called the Turkey—cement, used by the Turkish jewellers in setting their precious stones, and which is stated to possess such adhesive powers, such cohesive strength, that it will secure firmly together plates or parts of polished steel. And in ordinary work, if the force employed is really sufficient in amount to cause fracture of the body, that fracture or separation will take place at some point other than that at which the parts were cemented. This cement has for its basis "isinglass"—the true or fish isinglass being here meant, not some of the modern gelatine preparations so called—gum mastic, and gum ammoniac or galbanum. The dissolving medium is spirits of wine or rectified alcohol of the standard strength. Of the isinglass, in the first instance, take, say, two ounces: the quantity will vary, of course, with the amount of cement desired, but the proportions here named must be observed. Soak the two ounces of isinglass in pure or distilled water, in quantity sufficient to soften it; after which dissolve the softened isinglass with as much of the spirits of wine or rectified alcohol as will make a fluid about the consistency of thickish—not thick—cream. When properly dissolved —under the application of a gentle heat the solution will be made more quickly and uniformly—take the gum ammoniac or galbanum in the form of little globules, technically called "tears," and to ten grains of this add portions from time to time, mixing and rubbing it up together with the dissolved isinglass. Take now in a separate glass or vessel six grains of the gum mastic, in the form of larger "tears," and dissolve them in just as much spirits of wine as will make an absolute solution and no more. Take this thick solution and add it to the mixture first made as above, and mix the whole intimately together. The Armenian or Turkey cement will now be ready for use. But certain points in using it should be observed; and this remark is equally applicable to all other kinds of cement where the best results are desired—and this ought always to be so, otherwise it is, in the true and common-sense view of the matter, altogether useless to make the cement at all. In the first place, the surfaces to be joined must be made clean, perfectly free from greasy matter. Hence, to obtain this in the most perfect way, the sooner the cementing is done after the object is broken the better, the fractured edges being thus obviously in the natural condition of the material, and free from dust or greasy matter. Care, therefore, should be taken not to touch the surfaces with the fingers, for those of the "daintiest lady in the land" are, in a true sense, anything but clean or free from greasiness. If the fracture has been made for some time, or should there be any doubt as to the cleanliness of the edges of the fractured parts, they should be washed with a weak solution of ammonia liquid, and allowed to dry before the cement is applied. And before applying this, care should be taken to have the edges joined precisely in the line of fracture. If this precaution be neglected, it is obvious that a perfect joint cannot be obtained. The best way to deal with the parts is to place them on a flat surface, as on a wooden board, and place the parts in due relation to one another; and if there be more than two parts, two should be cemented and dried before the third part is taken in hand, and so on. In the case of parts of a new body, the surfaces of the joints should be carefully prepared, truly levelled, and made flat throughout, without any protuberances or hollow

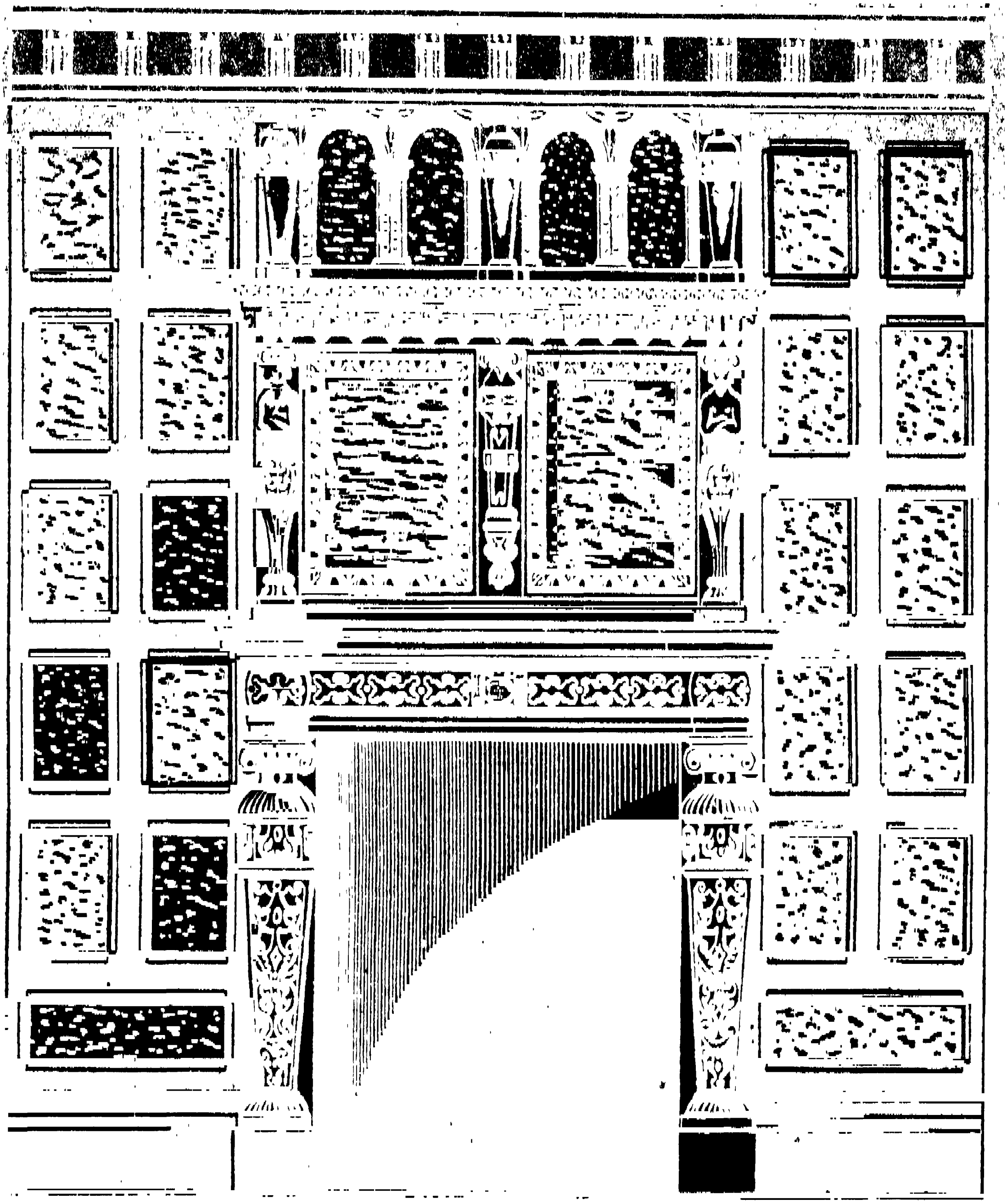
parts; if these exist no true joint can be made. The cement should be applied very thinly and uniformly all over the surface of each edge, and these when brought exactly together in the line of fracture—if a broken body is being dealt with—are kept closely pressed together for a short time. When pretty broad surfaces are to be joined, and the parts admit of the treatment, the cemented joint will be all the more perfect if the parts, while they are being pressed closely together, be moved to and fro—one surface upon another. This can only be done for a short period, as the cement will soon take such a hold that movement will not be possible. The great object in cementing is to press out all the air between the surfaces, and to bring them in actual contact all over their spaces. All cements should be so kept as to prevent dust from mingling with them; the bottle should therefore be carefully stopped, or the jar covered with a light cover. They will best be melted by placing the lower part of the bottle or jar containing them in hot or boiling water.

(24) In a preceding note on "Fuel and its combustion," in referring to the kindling of a common kitchen fire, as illustrating familiarly all the points of this important subject, we stated that the combination of oxygen of the air with the constituents of the fuel which under the influence of heat created combustion was not immediate or even very rapid; that time or a preparation of the fuel was necessary, or what a high authority terms a "species of cooking" was essential, and the higher the heat within the burning mass the better the "cooking," the more efficient the combustion as a heat given. The intelligent domestic knows this practically, although she may have no conception of the reason why. She knows, therefore, that the more she concentrates the heat in the centre of the grate, or rather the burning fuel, by keeping the kindling material close together, the more quickly will she have the coals burning brightly and her kettleful of water boiling. If, however, not observant, she, on the contrary, spreads the kindling material all over the grate, the kindling is a slow process. This circulation of the heat, this conservation of it within the mass of burning fuel in a grate lined at the back and sides with fire-clay lumps—a first-rate non-conductor of heat—is the secret why fuel always burns brighter and consumes more completely away in a grate so lined than in an iron grate, which keeps the fuel burning languidly, the iron leading off or conducting the heat away from the fuel, thus lowering its temperature. This conservation of heat, this maintenance of a high temperature in the mass of burning fuel, is not always attended to in furnace construction and management, and is the secret of some boiler furnaces the success of which surprises many, as there is no apparent difference between them and others which would account for their success. The whole question of the "condition" of the fuel an influencing combustion underlies all the points of successful practice; and it is to neglect of this essential consideration that we owe much of the wasteful methods of furnace management but too frequently met with, and in it lies the secret why one man with the same materials and under the same circumstances gets as much work again out of coals as another. Let us examine a little further into this question of "condition" of fuel as influencing the process of combustion; and in doing so let us return to the familiar illustration of the kindling of the kitchen fire, in which all the phenomena of combustion are exemplified. If, in place of leaving the paper—which the domestic uses as one of the kindling materials—in a loose, free condition, she folded it up into small compass and pressed it lightly together,—and if in like manner, in place of having the wood in small "handy pieces," she had it in the form of one or at most two heavy "clubbocks,"—and further, if in place of "nice nobbly bits of coal" she had one large lump of coal,—stupid as she might be, she could scarcely be so very stupid as not to know that there would be small chance of kindling her fire quickly, if indeed she could have any chance of kindling it at all. But if she be intelligent and observant, she will know that it is necessary to have the paper free and loose, the wood or chips small and short, and the coals in nice smallish pieces; moreover, that it will save time if she be at the pains somewhat carefully so to build up her kindling materials that, disposed in layers one above the other, the paper first, the wood above this, and finally the coals, the air will have free access to them when once they are kindled, so that it will become quickly heated and enter freely into combination with the carbon and the hydrogen of the coal. And with regard to the coal the domestic will—if observant and thoughtful—soon learn that fresh coals will kindle much more quickly and burst into flame and lively combustion, than the same coal burned into the condition of cinders, or "coke," if used as fuel,—the reason being, though she may not know it, that the cinders and the coke alike have had in different ways the bituminous matter of the coal, yielding the hydro-carbons and different gases, distilled away, and that they are then difficult to kindle, and require a high temperature to make them burn as clear, red-hot incandescent fuel. The condition of a fuel is nearly everything in relation to its quick and complete combustion.

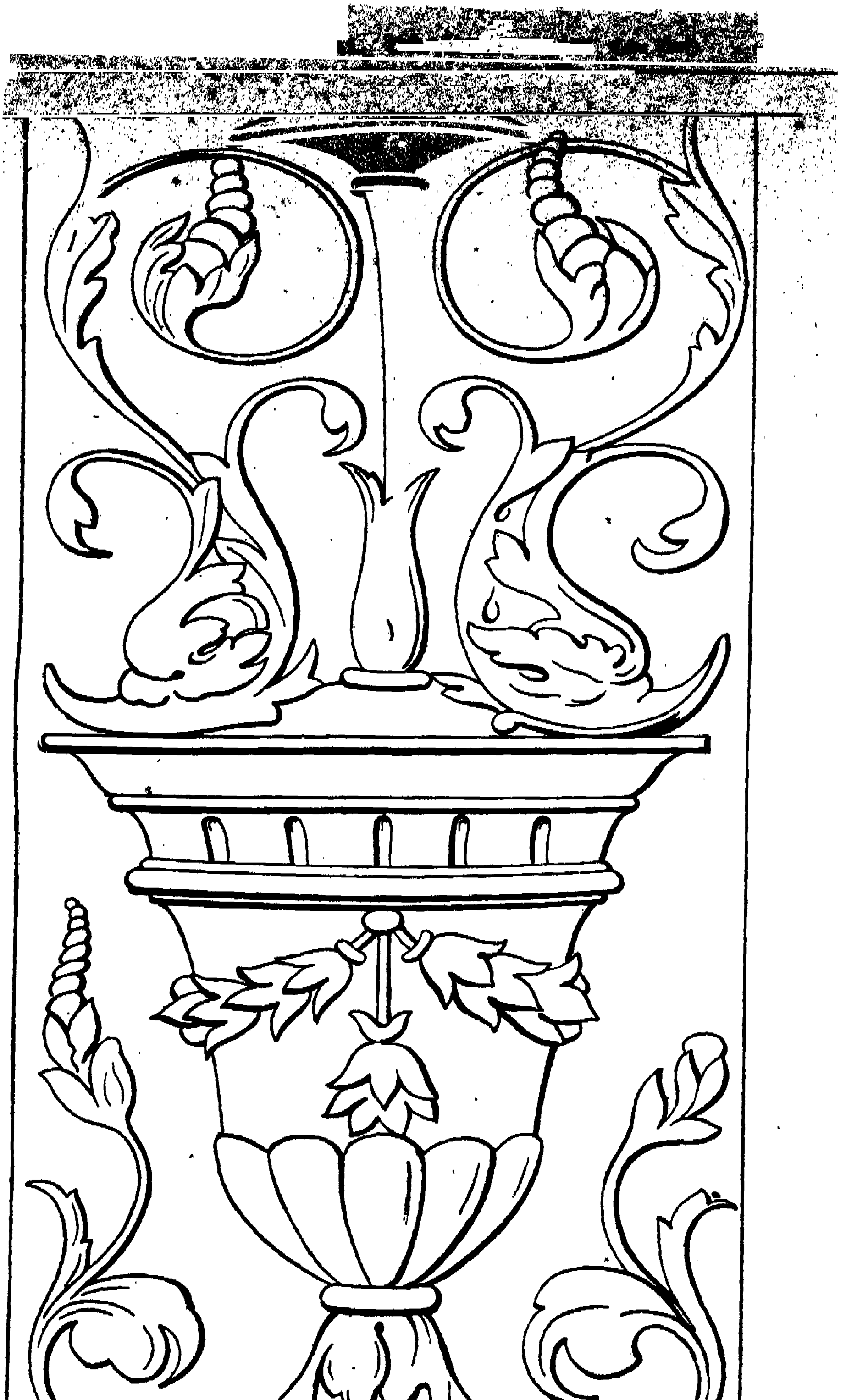
(25) We concluded our last Note on the subject of boiling of water for steam raising (see Note No. 22) by stating that we had much yet to learn as to the best

mode of boiling; but that recent researches and discoveries justified the hope that before long the steam engine boiler of the—perhaps—near future would be an immense improvement upon those which now principally dominate the market. If it be true that the present steam engine—and be it remembered that the boiler is as much a part of this as the lungs are of the human body—is the most wasteful contrivance for utilising heat—and this the highest authorities declare, seeing that we obtain or retain for effective work but a very small percentage of the units of heat due to the combustion of fuel—there is surely good ground for our statement that a much better mode of boiling —evaporating—than the one which now dominates is still a necessity. At this stage of our inquiry the question arises, What, then, is boiling? As we have already said, there have been several definitions of boiling; but some, while they tell us how boiling is effected, give us no information as to what boiling is. It is not the evaporation of water, as some tell us; for evaporation takes place at all temperatures, and water exposed to the air will dry up—evaporate—in winter as well as in summer. Others say that boiling of water is only effected by evaporation carried on at a temperature of 212° Fah., which hence is called the boiling point. But this is only true so far as it goes, and under certain conditions—as when the barometric pressure is at, in round numbers, thirty inches, which is that generally existing at the sea level. But alter the barometric conditions—that is, the air pressing on the surface of the water (15 lb. to the square inch at the sea level); lower the pressure, the boiling point temperature no longer stands at 212°, but lower in proportion to the decrease of atmospheric pressure. Increase the pressure upon the surface of the water, and the boiling point rises above 212° proportionally. But when even under the average barometric pressure of thirty inches, the boiling point will rise and fall under certain circumstances in the operation of boiling. Thus it was very early discovered that the very material of which the vessel was made in which the boiling was carried on affected the temperature of the boiling point, raising or lowering it according to circumstances. Further, that in the same vessel the indications of the thermometer were dependent upon the position in which the bulb was placed: thus, it showed a different temperature when placed in the steam space from what it did in the water space of the vessel in which the boiling was going on. Let us examine further into the phenomena displayed in the boiling of water—say, in the glass retort or flask of the analytical chemist, in which a spirit lamp placed in the retort stand, below the retort, is the heating medium, and which when once adjusted may be relied upon as a source of heat nearly constant in temperature—not fluctuating, as in the case of a common fireplace; commencing the simple experiment with the flask or retort filled up within an inch or two of the top of neck. Amongst the first phenomena observable will be the rising of the water level: probably it may rise to the very edge of the neck, or it may even rise so high as to flow over the edge. This is evidence that there has been a repulsion of the molecules of water, causing them to occupy more space than before. This is clearly an indication of the "force" created by the heat, as the repelling force has obviously overcome a force greater than the normal attraction of the molecules. Watching the phenomena as they arise, it will be observed that a series of clear, bright bubbles form, and become more or less clustered on the bottom and partly up the sides of the flask. As the heat of the lamp is constant, a larger and larger amount of heat increments is taken up by the water, and the clear bubbles will be seen to detach themselves from the glass, and rising to, break through the surface and pass into the atmosphere. These bubbles are filled with an invisible vapour, the vapour of water which is virtually steam; and it will be noticed that the bubbles as they pass from the surface of the water in the flask are less in bulk than when they rested on the bottom of the flask. This arises from the fact that the bubbles as they rise from the bottom, at which point the water is the hottest, reach a level in the body of the water at which its temperature is much lower or cooler than the water at the bottom of the flask. Passing through this colder stratum of water, the vapour in the bubbles is partly condensed, adding thus to the heat of the water at that level, and the bubbles, now much smaller, rise to and pass from the surface of the water. As the increments of heat are added to the water at the bottom of the flask, and this becomes hotter, the bubbles rise more quickly; and as the level of the cool portion of the water is changed, the condensation is less and less marked, till at last, the whole body of water becoming of uniform temperature, there is no further condensation of the bubbles of vapour; these, therefore, rise rapidly to the surface, and are passed away as steam, taking the form of a white cloud of vapour. This is what is popularly called "steam,"—but it is not the true steam, which is an invisible vapour when formed, but being partly condensed by the colder atmospheric air, it becomes visible. If a few glass globules, or other light floating bodies, were placed in the flask, the existence of a continued current would be made manifest, the globules being carried down by the colder strata of water towards the bottom of the vessel, and upon this getting heated would rise, till by the uniform temperature this continued current would largely cease. These currents are caused wholly by the heat, and are in themselves manifestations of a force, the result of the heat increments passing from the heating lamp to the water in the flask.

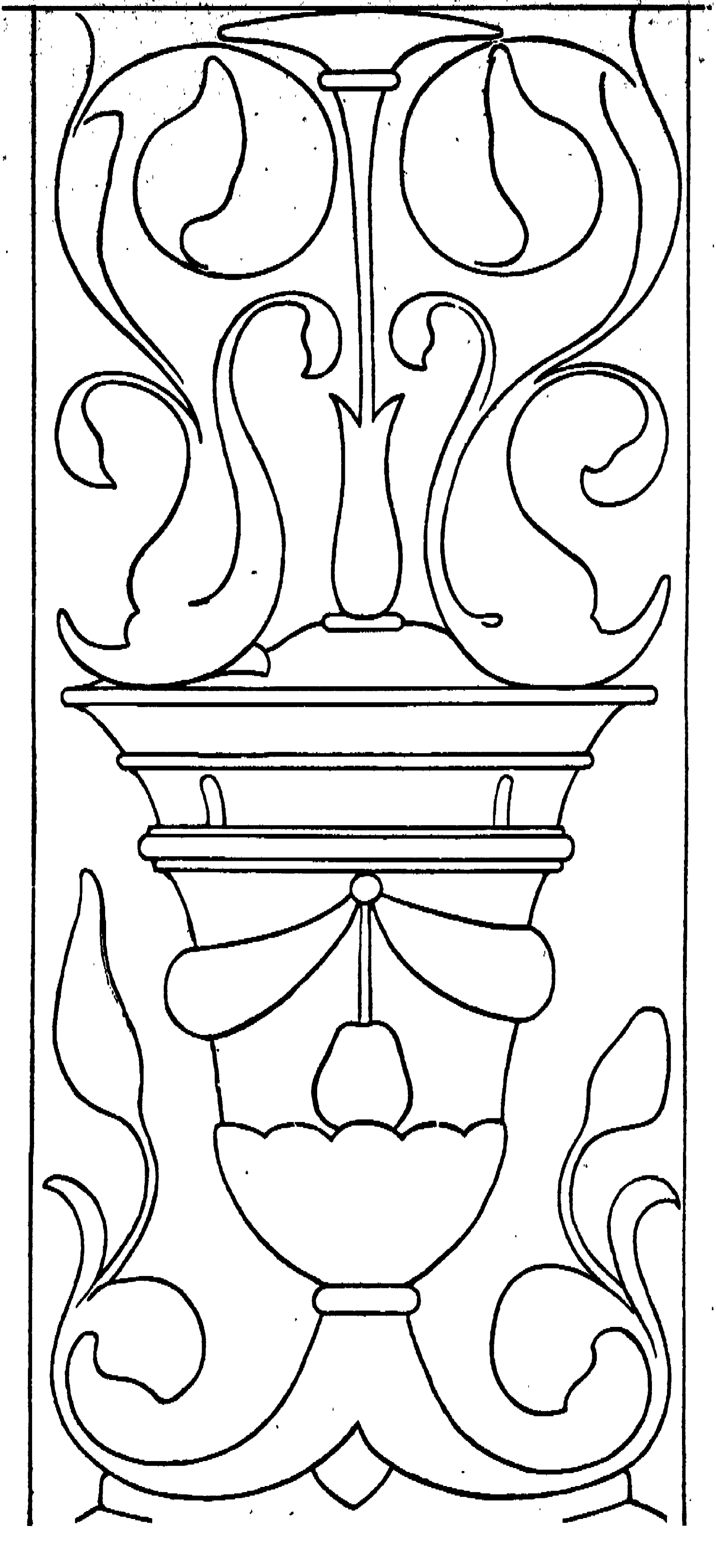
THE CABINET MAKER (see Text).



ELIZABETHAN CHIMNEY PIECE

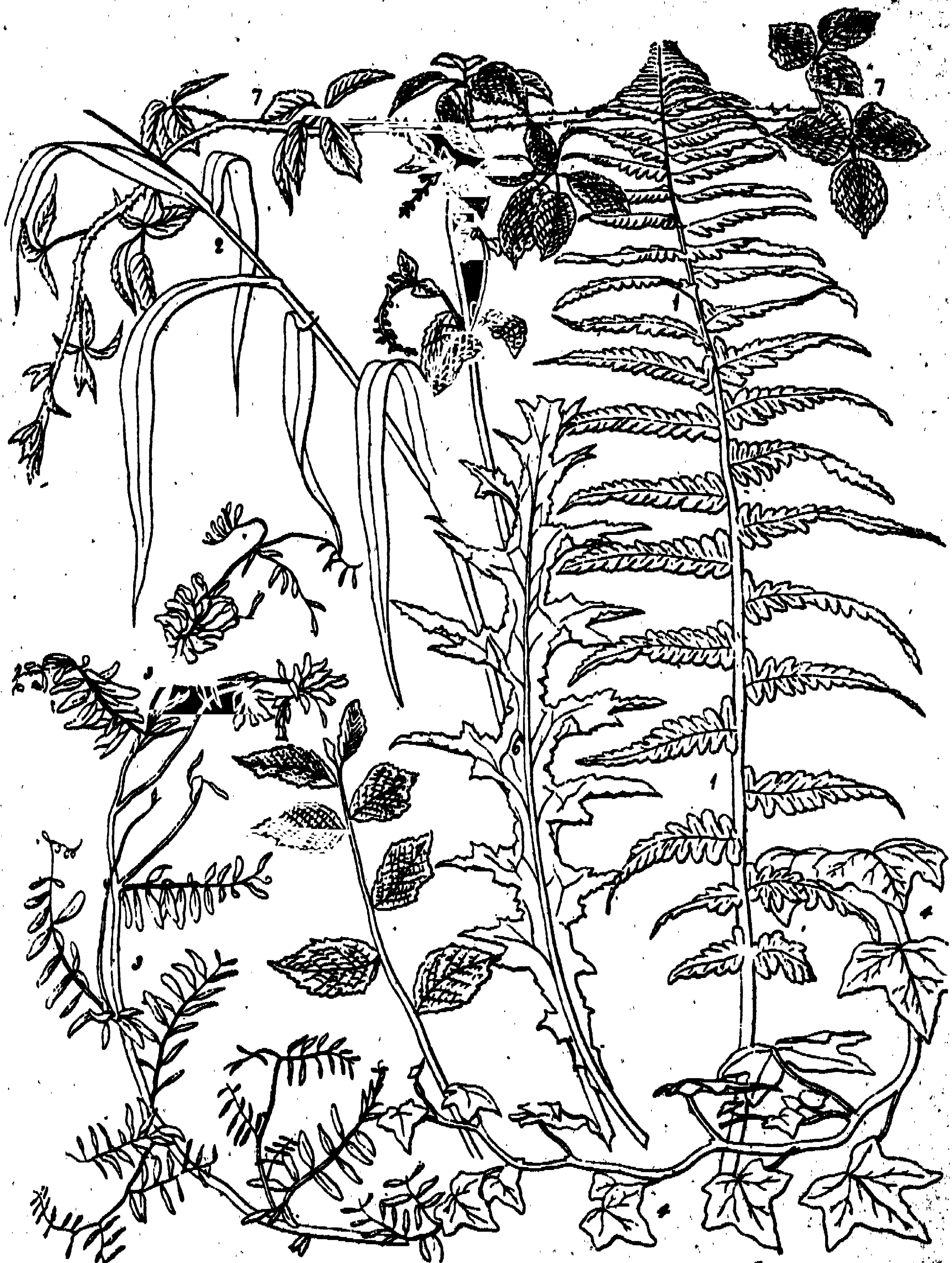


Block of Subject in Plate LVIII.



FORM AND COLOUR IN INDUSTRIAL DECORATION (see Text).

NATURAL FORMS APPLICABLE TO DECORATION.



(1) FERN (2) GRASS (3) VETCH (4) IVY
(5) BEECH LEAF (6) THISTLE (7) BLACKBERRY & BRAMBLE

THE CARPENTER (see Text). ROOFS AND DETAILS.

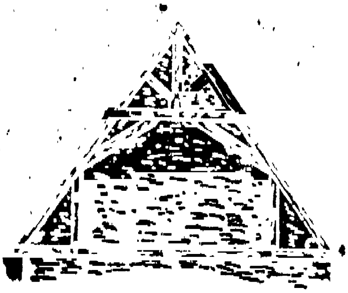


Fig. 1.

Gothic or
Roof

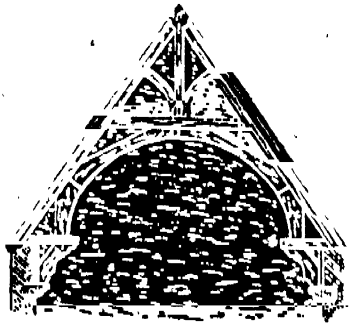


Fig. 2.

High-pitched
Trusses.

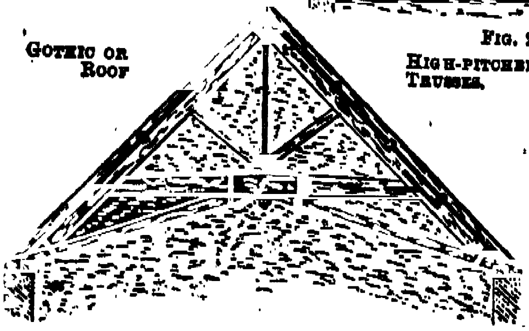


Fig. 3.

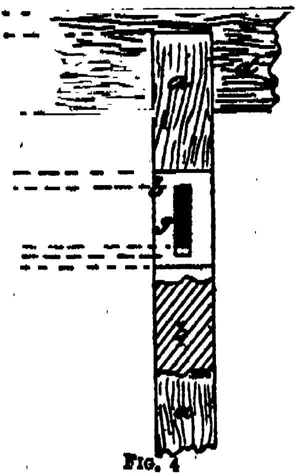


Fig. 4

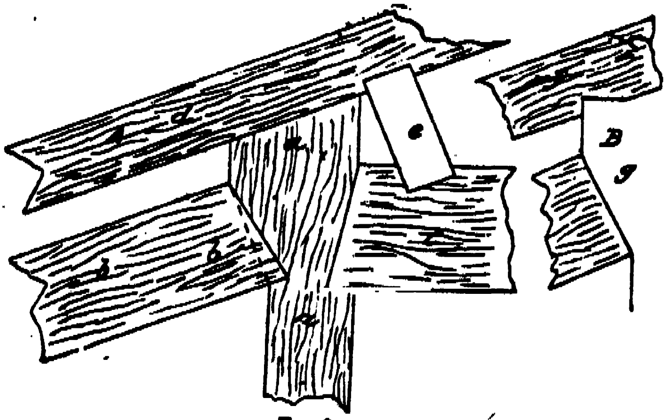


Fig. 6.

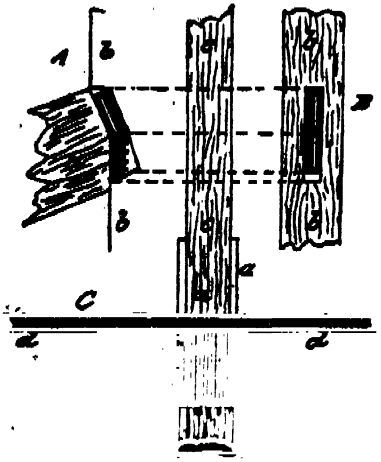
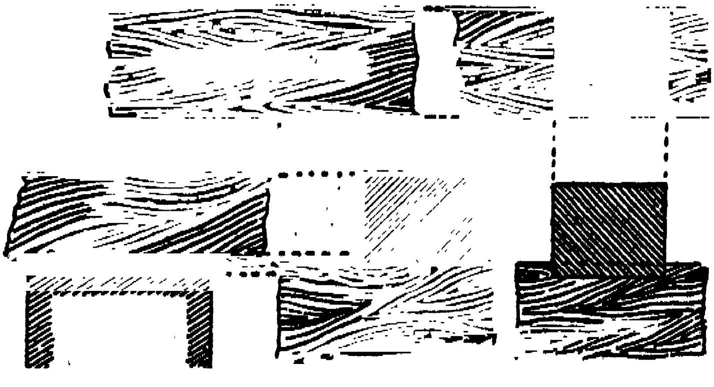


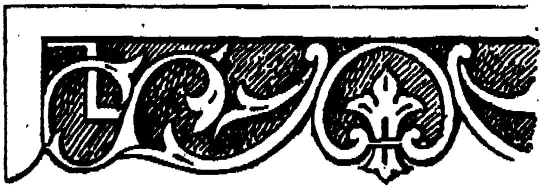
Fig. 5.



of Joints in
Roofs and Floors

ELEMENTS OF DECORATIVE CARPENTRY AND JOINERY.

OR THE EXTERIOR WORK OF BUILDINGS, TIMBER STRUCTURES, ETC., ETC. (see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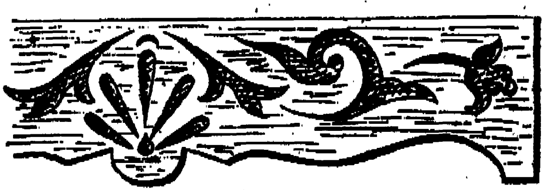
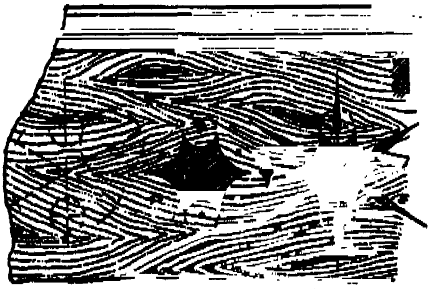


FIG. 2.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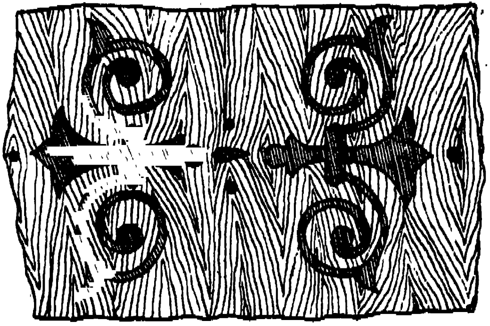
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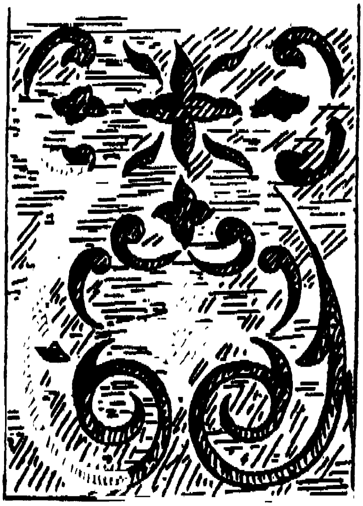
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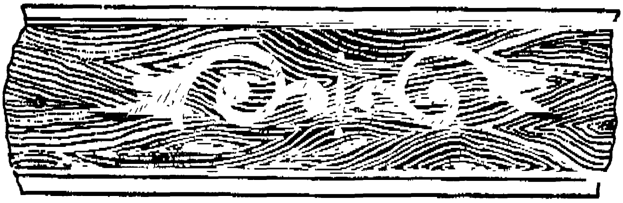


FIG. 6.

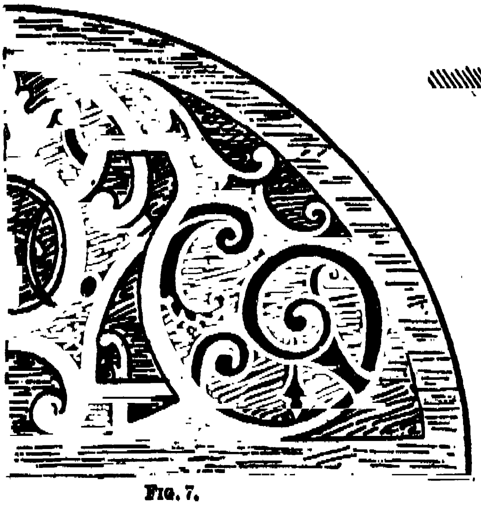


FIG. 7.

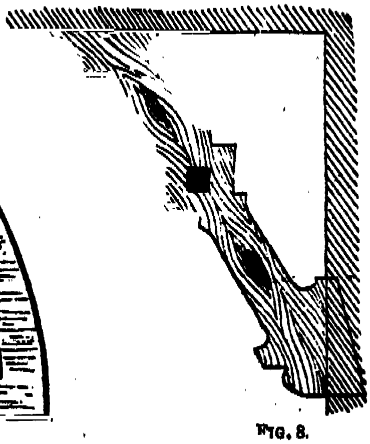


FIG. 8.

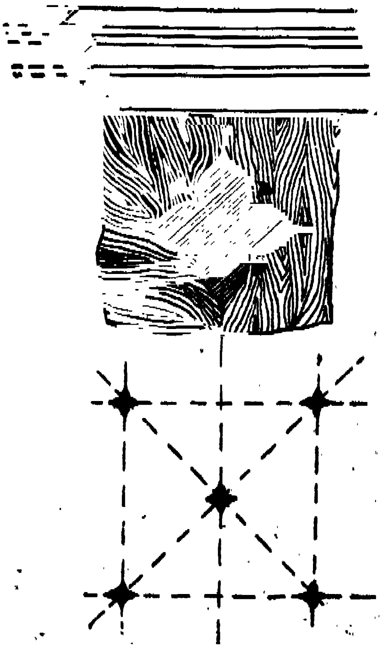


FIG. 9.

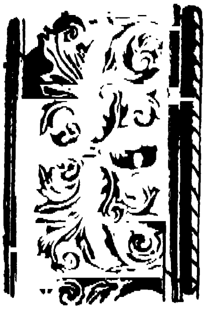
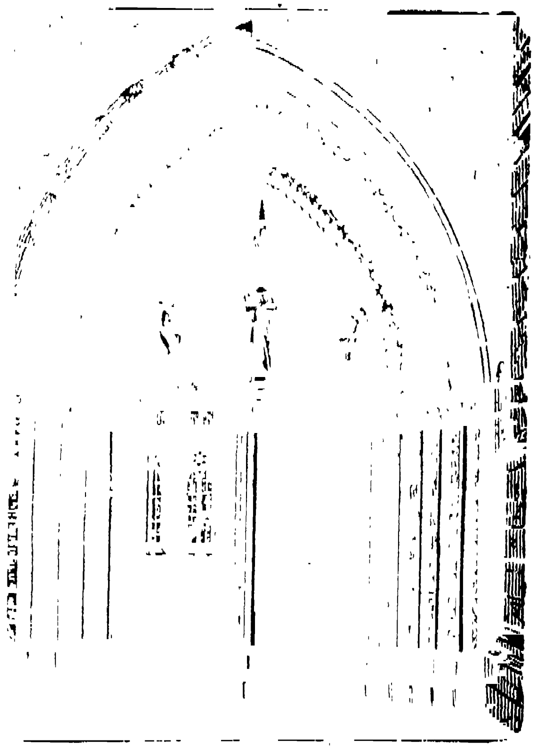


FIG. 1



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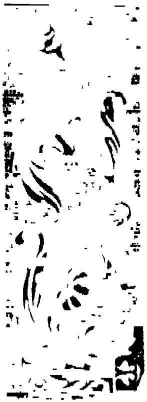

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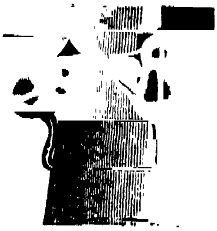

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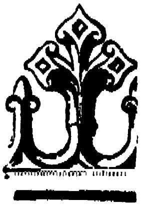

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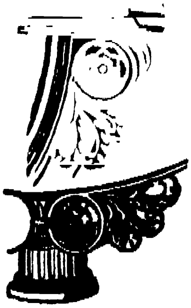

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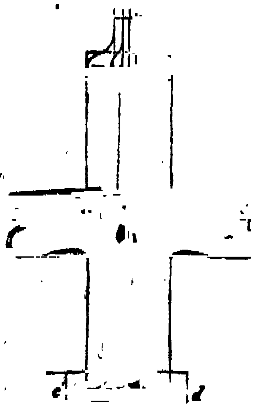

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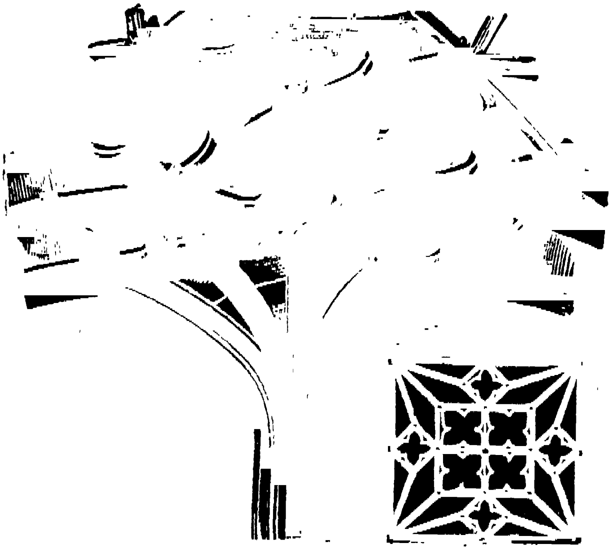


FIG. 7.

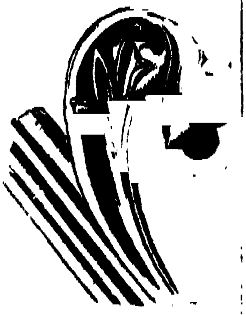


FIG. 9.

THE STEAM ENGINE USER AND GENERAL MACHINIST (see Text).

DETAILS OF STEAM ENGINE. — ECCENTRIC FOR FORCE PUMP (see Supplementary Sheet No. 2).

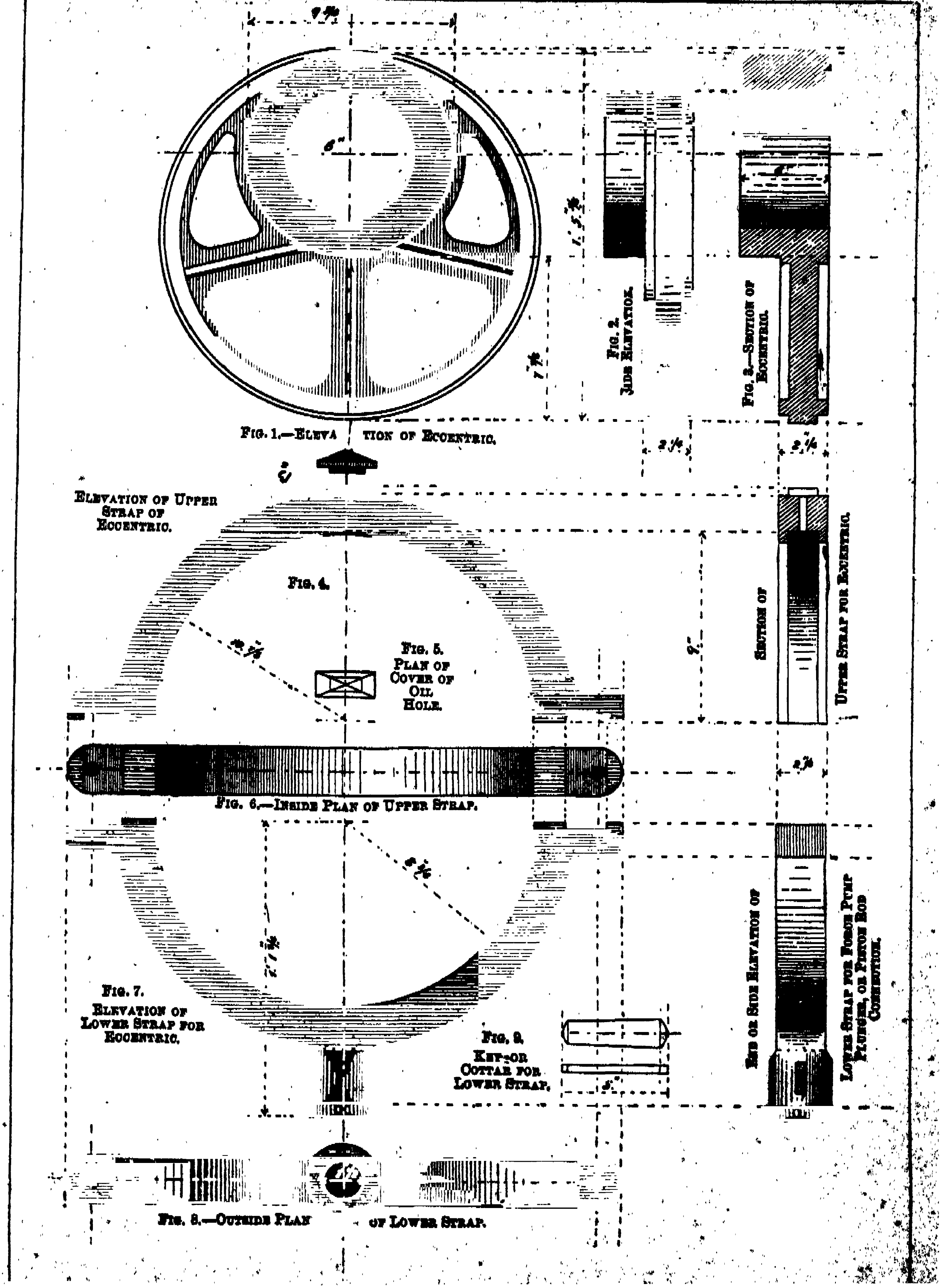


FIG. 1.—ELEVATION OF ECCENTRIC.

FIG. 2. SIDE ELEVATION.

FIG. 3.—SECTION OF ECCENTRIC.

ELEVATION OF UPPER STRAP OF ECCENTRIC. FIG. 4.

FIG. 5. PLAN OF COVER OF OIL HOLE.

SECTION OF UPPER STRAP FOR ECCENTRIC.

FIG. 6.—INSIDE PLAN OF UPPER STRAP.

FIG. 7. ELEVATION OF LOWER STRAP FOR ECCENTRIC.

FIG. 9. KEY OR COTTAR FOR LOWER STRAP.

END OR SIDE ELEVATION OF LOWER STRAP FOR FORCE PUMP PLUNGER, OR PISTON ROD CONNECTION.

FIG. 8.—OUTSIDE PLAN OF LOWER STRAP.

THE STONE MASON AS A TECHNICAL WORKER.

The Principles and Practice of, and the Materials he employs in, his Work.

CHAPTER V.

Ashlar and Coursed Rubble Work combined in Windows.

In fig. 30 we illustrate another combination of ashlar work with coursed rubble. This shows the disposition of stones in a wall in which there is a window opening, as *a a*. Technically, all openings, as doors or windows, are called "voids"—that is, empty spaces or vacuities, by which the continuity of the wall is interrupted. The void or opening is "spanned," or, so to say, bridged over, by a long flat-surfaced single stone, *b b*, called a "lintel," the corresponding stone *c c* at foot being called the "cill." The "ashlar" quoin blocks are at *d d*, the interior filling between them being of coursed rubble work at *e e*. Another void — the arrangement of window being known as a "two-light"—is shown in fig. 31, the wall or "pier" between them being in ashlar work. In place of coursed rubble, as at *b*, the wall may be formed of irregularly shaped stones, as at *c*, and each stone very carefully "pointed,"—for which operation see a succeeding chapter. A variety of window lights with their stone dressings will be found illustrated in the paper entitled "The Domestic House Planner," and in the Supplement sheets embracing examples of the styles of Domestic Architecture.

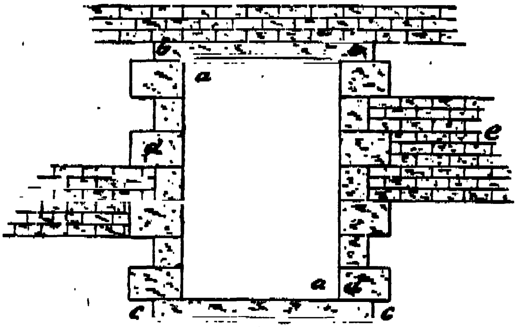


Fig. 30.

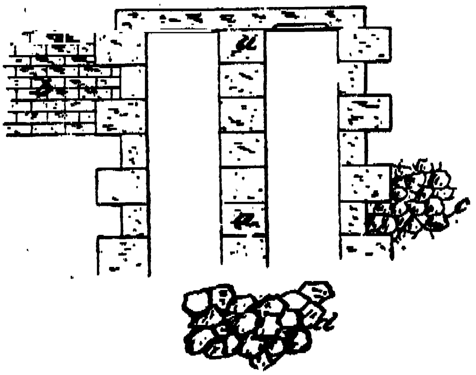


Fig. 31.

Chamfered Work in Stone Lintels, Cills, etc., etc.

The lintel *f* in fig. 30 and the cill *g* are shown with a double line at the bottom edge. This does not continue along the whole length of the lintel edge, but is seen to stop short of the cills, being terminated by curves. This method of finishing the edge of a block is called technically a "chamfer," and how it is done requires further illustration. When two sides of a block meet at right angles, the corner or sharp edge formed is called an "arris." Taking the arris off a block, either by way of making a sharp corner into an easy rubbing surface, as at the side posts of a door, or for giving the variation to the outline, more or less ornamental as it is supposed to be, is simply cutting a part of the corner off by paring, planing or sawing, in the case of wood, or by the chisel in case of stone. A corner so treated is shown at *a* in fig. 6, Plate III., in section, and at *b* in elevation. This "taking off the arris" from a block is sometimes otherwise called "bevelling" or "splaying" (see "The Bricklayer" for an illustration of a splayed brick), generally a "chamfer." In some cases the bevelled portion continues to the end of the block, as at *b*. But if it stops short of the end, as at *e*, it is called a "stop chamfer," and may be finished as there shown. It may terminate with a curved line, as is done when the "bevel" or "splay" is straight-faced, as in fig. 32; but if the arris be taken with a curved face, as shown in the sketch to the extreme right of fig. 33, the "stop chamfer" terminates with a curved line, as at *d*. In fig. 6, Plate III., *e e* shows in plan the stop chamfer curved in face, as in the section at right of fig. 33. Fig. 32 further illustrates plain and curved-faced chamfers (see the paper entitled "The Joiner" for further illustrations of "chamfers," and the "Cyclopædia of Technical and Trade Terms" for the meaning, derivation and foreign equivalents).

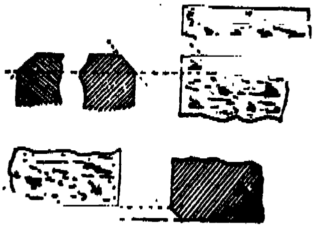


Fig. 32.

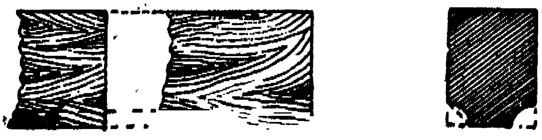


Fig. 33.

"Weathered" and "Throated" Window Sills.

The "sill" of a window, as at *c* in fig. 30, is generally cut or wrought in a peculiar way. This is illustrated in fig. 34. The sill is not made flat-surfaced, with the top parallel to the bottom line—that is, with the front face of the same depth as at back—but slopes downwards from a certain point to the front edge, the slope having as its height the distance as shown by the dotted lines in fig. 34. This slope is given to the upper surface, part of which projects beyond the line *d* of wall, in order that the rain may pass away from the top of the sill, and running down the front face, drop to the ground as at arrow *c*. This sloping surface, shown in complete sill at *ff*, fig. 34, is what is technically termed "weathered." But a little consideration will show the pupil in masonry that when the rain passes down the front face of the sill, on reaching the corner it will be apt by the force of capillary attraction—or maybe blown inwards by the wind, in, towards and along the under surface, and by this means—to pass to the wall, as indicated by the arrow *b*, fig. 35. Now, it is an object of importance to keep all rain "drip" from reaching a wall. This is prevented in the case of the sill by cutting in the under side of it near the wall a groove, as *d*, running along from end to end. On the water or "drip" reaching to the outside edge of this, it cannot of course pass across the opening of groove or upwards within the groove, and therefore drips to the ground.

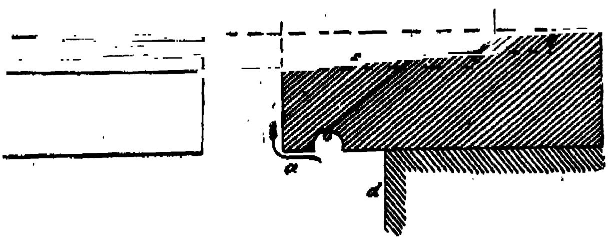


Fig. 34.

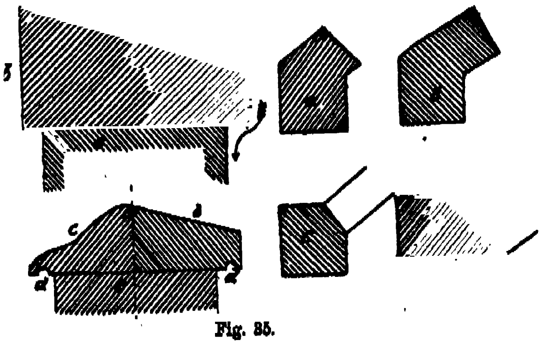


Fig. 35.

Coping Stones, "Weathered" and "Throated."—Angle Quoins.

Enclosing walls are generally finished at the upper part or top course with a line of stone blocks. These are sometimes weathered on one side—that is, they have the sloping surface to shed off the rain on one side only, as in the diagram to the left in the upper part of fig. 35. Usually, and in good work, the coping stones are weathered or sloped on both sides, as shown in the diagram below. The sides are usually plain, as the side *b* to the right of centre line. They are sometimes curved with an ogee curve (see the separate paper on "Mouldings," forming one of the sections of the leading paper entitled "The Technical Points connected with Form and Colour in Industrial Decoration), as at side *e*. In this diagram the coping stones are "throated," as at *d d*. When window or door voids are arched over in place of having a flat lintel, as in fig. 30, and are dressed with quoins at the sides, the quoin block at the top of each side of opening is cut with an angular face to serve as an abutment for the springing arch at top. This may be, as at *c* or *d*, to the right of fig. 35, or the blocks may be cut as at *a* and *b* in diagrams above the last-named, part serving for the vertical part of the quoin, and part for a portion of the springing arch.

Methods of Bonding or Joining Stones other than those already described—Connecting Stones Mechanically—Description of Various Methods with Details.

Before proceeding to illustrate the various forms into which stones are cut in order to serve as part of buildings, domestic or otherwise, it will here be necessary to go further into the subject of "bond." This, however, only so far as methods other than the principle of bonding the stones of a structure together which we described in the latter part of the preceding chapter. That principle of placing or disposing the stones of a structure so that they shall interlock, so to say, with one another, constitutes what is "true bonding." There are other methods which are more purely mechanical, inasmuch as some of them demand a special treatment or cutting of the stones so as to form special interlocking or dovetailing parts by which the stone are mechanically held together. In other methods special appliances purely mechanical, and for the most part formed of iron or wood (chiefly iron), are used. All the methods comprised under these two classes may be termed methods of bonding stonework supplementary to what we have called the true principle of bond, or "mechanical bonding." This "true bonding" here referred to may also be termed the natural method, being intrinsic, so to say, to, or purely characteristic of the stones themselves; each as affording the means to bond with its neighbour according to its placement or disposition in the wall or general structure.

THE LAND DRAINER.

DRAINAGE OF LANDS OR SOILS SUITABLE FOR THE CROPS AND LIVE STOCK OF THE FARMER.—ITS HISTORY, PRINCIPLES, AND PRACTICE.

CHAPTER II.

AT the conclusion of the preceding chapter we stated that drainage improved dry soils, such as those of sand and gravel. The way in which poor arid soils are improved is, that the stones or particles of which they are composed may contain clay as a component, and by the action of air and water, afforded by draining, disintegration of such particles takes place, thereby furnishing clay by which the soil gradually becomes more and more retentive the longer these agents continue to act, until at length the soil becomes sufficiently retentive of moisture to support healthy vegetation. It may here be noticed that a similar action takes place when manurial matters are carried down to such soils through the agency of town sewage irrigation carried out in conjunction with good drainage. Hence one of the great advantages of this class of irrigation in soils such as here named. As is well known, they are specially adapted, markedly in the case of sandy soils, for the utilisation of town sewage. (See "The Irrigator.")

Importance of Good Design in Draining Operations.—Systematic laying or setting out of the Drains.

A frequent cause of inefficiency, and at the same time of unnecessary expense, in draining at the present day, is want of comprehensiveness and system in laying out or designing the work. This may be exemplified in such a case as a single field, or several contiguous enclosures, in a farm or estate being drained without due provision being made at the time, either in the direction or depth of the outfall, or branch main drains, or the size of the ducts of such drains, for their being made available for carrying the drainage of an extended area of ground to be drained at a future time; or that it may not in any way interfere with the efficiency of such future draining. The extra cost of lifting and relaying a portion, or perhaps the whole of the main drains already executed, with the junction of the small or feeding drains, may be the least evil consequences of such want of foresight. The test of skill in designing draining operations is effecting the thorough drainage of the greatest extent of ground with the fewest outfalls and the least length of main drains. This can only be attained by experience and attention in the art, and the most careful observation of all circumstances that can in any way bear upon the operation, not only in the immediate locality of the work in hand, but also in the surrounding district; and to this must be added that most essential property in the skilful drainer of *foresight.* No draining, of even the smallest extent, should ever be commenced without first having the leading drains traced upon a correct plan of the ground upon a large scale, and every consideration given to after extension of the operation, before finally deciding upon the direction of such drains; and a correct section of the course of such drains should also be prepared, for which the levels should be taken at not more than one chain's length apart.

Ability in designing, and Skill in carrying out, the Details of a Good System of Land Drainage.

The last cause of the anomaly spoken of requiring to be noticed is the incompetency of the persons frequently entrusted to design and superintend so important a work as the draining of cultivable land. Farmers, at least those of the past day, were not always possessed of sufficient scientific knowledge to design and sufficient technical skill to superintend the execution of all the work with that accuracy which unfailing success, and the utmost economy, in draining requires. The vocation of the farmer is not always the most favourable to that training of mind and exercise of thought which deals with the various combinations of circumstances which drainage of considerable extent frequently demands; and it is not always that the mere farmer will give that careful attention to the effect of more simple circumstances which will in most cases influence the success of draining. However unqualified the persons just named may be to design and superintend the execution of draining operations of considerable extent, or in any way of a complicated nature, with certainty of successful effect, still more so must be many persons who follow land draining as a business of life, and who, being often without the rudiments of the most simple education, must find it difficult, if not impossible, to succeed in an undertaking requiring, in its proper execution, not only considerable scientific attainments, but also great experience in the art, careful observation of circumstances, and much foresight. And yet to such persons work is entrusted, not only of considerable extent, but also frequently under great complexity of circumstances, to be designed, and its execution superintended. Where such a class of persons is so frequently employed to conduct the operation of draining, the wonder is that it should ever succeed, not that it so frequently fails in being thoroughly efficient.*

In order that so important an operation as land draining may be infallibly efficient and economical, as it might be, men fully qualified to design and conduct the undertaking should be employed to consider all the circumstances which may have an influence on the operation; to prepare a comprehensive plan of all the leading drains; and to report on the best mode of conducting the work, and the cost of carrying it out to a successful issue. This, since the ordnance maps, which being supplied to the public at a merely nominal price, have superseded the necessity of a special survey for a plan of the ground to be drained, may be done at a very insignificant cost. Accurately prepared sections of the leading drains, a properly drawn specification of the work to be executed, superintendence of the work whilst in progress, and certificate of due compliance with the specification of the work when completed, may all be had at a very moderate charge, not in many cases exceeding five shillings an acre—an amount small in comparison to the cost of the consequences already pointed out as likely to arise from the errors of incompetent persons being employed in a matter of so much importance as land draining—an operation on which improvement of the fertility of the soil in the first and greatest degree depends.

Brief Glance at the History of Land Drainage, with some Suggestions flowing out from it.

Before entering upon the practical details of the art of draining lands or soils fitted to grow farm crops, we shall take occasion to glance at a few of its historical features, as those are calculated to convey something, if not of an absolutely practical character, at least of what may suggest points of some value. As in other of what may be called the primary arts of civilisation, in which the immediate support of life and much of its comfort is secured more or less directly, we have to go back to the time of the Romans for the earliest notices of the practice of the art of drainage. Those wonderful people were essentially a working people, and although far from disdainful of all those things which minister more to the luxuries than to the necessities of life, they, at least up to the later and the last periods of their national existence, when luxury was thought more of than labour, were distinguished for the close care they paid to all kinds of practical work. Of all the primary arts of civilisation, that of agriculture is the essential one which must precede all others and be carried on without intermission or neglect, if succeeding arts—life, indeed, itself—are to flourish. Hence we find that they paid great attention to farming, and some of their methods, contrivances and mechanical appliances, foreshadowed or anticipated by many hundreds of years what form now part of the work of the modern art. Drainage was not overlooked, nor its advantages altogether unattained, through lack of methods of carrying it out. Those we find more or less clearly, or as we might with perhaps greater truth say obscurely, explained by several of the Roman writers of poetry as well as of prose. They were, as may be readily conjectured, simple, if not of the simplest in character; and that their form was handed down and seen exemplified in the practice of this country hundreds of years afterwards, there is no reason to doubt. That during the latter period of their dominion in this country, tillage of land for corn-growing purposes—not its preparation and maintenance for purposes of pasturage, which, such as it was in all its neglected rudeness, formed for long periods the peculiarity of British agriculture—was carried on, there is abundant evidence to show. Perhaps the most striking part of this evidence is that of the land throughout the kingdom, especially in the southern parts, extending from the coast nearest the Continent to as far as Anglesea and the Isle of Man,—which latter indeed they, the Romans, called the granaries of the western provinces. That the land which is now and for many generations back has been occupied by pasture was under tillage in the times of the Romans is beyond all doubt. This (to quote the words of one of the most experienced, practical, and most intellectually cultivated of our modern writers on modern agriculture, now gone to his rest) is clear to "every one practised in agriculture who examines the ridges, furrows, banks, roadways, landmarks, cuttings, etc., still to be found; . . . when we reflect upon the time which has been spent in working up many of these old lands into their present ridges, and in ploughing down sides of hills into the breaks so often met with, and the care exercised in forming them to *free them of water*, we shall be convinced that those marks of cultivation were not found in the occasional breaking up of wastes for a temporary growth of corn, but owe their origin to an age of *continuous tillage* conducted with considerable skill and the use of ploughs very superior to those wooden stakes we see delineated on Saxon coins and drawings. . . . Those pasture lands, with all the indubitable marks of having been once under tillage or corn culture, are known by equally indubitable evidence to have been under pasture for ages. But other evidences of wide-spread tillage, in other and what would seem to be most unlikely places—even the very hill-tops in some districts—are to be met with. Any one at all acquainted with the internal condition of this country for ages subsequent to the departure of the Romans cannot possibly refer this high cultural condition of the land to the ever-varying and ever-restless hordes of invaders who came to 'harry the land of our forefathers,' still less to the undisciplined masses of those whom they invaded. And all history points, moreover, to the fact of the low condition of agriculture for long and long after the country became settled under the sway of the Normans. Nor to the Normans themselves, any more than to the mixed people into which the nation, so to say, concreted themselves, and which formed the same race we now talk of as English, who lived for a long period after the Norman sway was firmly established, could this high state of cultural practice be attributed.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER V.

Varieties of Pencils (*continued*).

At the end of last chapter we alluded to the fact that the draughtsman can now get for a penny a better quality of pencil than many of the shilling pencils of thirty or forty years ago. For, dear as they were, they were not to be relied upon; and we have known a shilling pencil to be frittered away nearly to the end in the vain endeavour to bring it to a point fine enough for work. To be sure, it is possible that the "pointing," may have been—very likely was—done in the wrong way; for in this process, as in all others, as we have already said, there is a good way and a bad one for carrying it out. And on this point of "pointing" we shall presently have a word to say.

We have used the word "brand" or "mark" as denoting the character of the pencil purchased. The brands used are such as F, which indicates that the pencil gives a fine or light line, neither too thick or dark, nor too thin or light—what may, in brief, be called a medium line, the "lead" being neither too soft nor too hard. In the descending scale of softness, as giving a dark, black, and broad line easily, we come to the brand of B, or black, and lower in the scale still is the B B, or "double B." But these three pencils are but rarely used by the architectural or engineering draughtsman, being chiefly employed for ornamental work, where shading more or less, and where dark, broad and bold lines are required. The F may, however, be used for many purposes, as for sketching architectural and engineering details, for "note-book" work, or for roughing-in working drawings and sketches on the board. The pencils used by the engineering or architectural draughtsman are all in the ascending scale of hardness above the F. The pencil next to this is branded as H, being a shade harder than the F. The next grade is the H H or "double H," and the next, generally the highest, is H H H, or "treble H," although pencils are made with the "four H" mark, which if true to brand are very hard indeed. The brands H H and "treble H" are those most frequently used, as giving a fine and light line, or rather a narrow hair-like one.

Fineness of Lines.

The fineness or "narrowness"—generally spoken of as thin in opposition to "thick," or more correctly "broad"—of a line is of importance. This will be seen when it is remembered that, in addition to other requirements in a line, it often happens that a centre point is required to be obtained by the intersection or cutting of two lines. Now, the narrower or finer those lines are, the more precisely can the point of absolute intersection or cutting be obtained. With very broad lines the point of actual intersection could not be easily ascertained. To make the pencil, even with its appropriate brand, give a narrow or fine line, it is essential that it be finely "pointed."

Pointing or Preparing the Pencil for Work, a Point of Some Importance to the Draughtsman in the Accurate Drawing of Lines.

To point a pencil properly for drawing, it is necessary that the point be long. The young draughtsman will see the necessity for this after he has, with thoughtful attention, drawn but a few lines along the edge of the T-square, which lines have to pass though given points previously marked upon the paper. If his pencil point be short and stumpy, he will find that the very thickness of the point will be the cause of his not actually seeing that the point of the pencil goes over or intersects centrally the mark made on the paper. Those marks are often of the very smallest, such as are made by the gentle prick with the fine point of a pair of compasses or spring dividers. And remembering this, it will be observed that it is necessary to have as clear a view as possible of the position of the point through which the line is to be drawn. If the young draughtsman will put the matter to the test, and try to draw a line through a given small point along the edge of the T-square—the thickness of which itself, be it noticed, here tends to obscure or hide the exact position of the point—he will see the importance of attending to this matter of finely pointing his pencil, and our remarks will be all the more fully enforced. Let him point a pencil as at A, and another as at B, in fig. 3; and let him try the two in drawing lines along the edge of the T-square to pass through points as finely put in as possible, and let him frankly say with which he feels most confident that the lines go through the points accurately, and with which he feels he can draw the easier. In the diagram A, the part from *a* to *b* is the pure uncovered lead of the pencil; from *b* to *c* is the tapering part of the wood. Some will be inclined to say that such a long

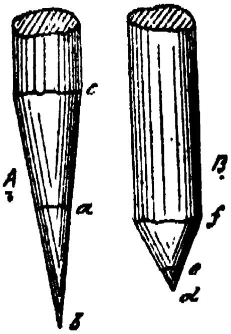


Fig. 3.

point of pencil lead as from *a* to *b* could not be made; that it would break off before it could be finished. No doubt it would, or will, if the trial be made in the rough, free-and-easy whittling style we have seen many attempt to point a pencil in. The operation, so far as it goes, is a delicate one, and as to the exposed lead part, that must be dealt with tenderly. Even with the greatest care, unless the lead be of high quality it is apt to break, even with the sharpest knife. The best plan to ensure a long and a perfect point, as from *a* to *b* in A, fig. 3, is to gradually and gently cut off the wood, and expose the lead from the point *b* to *a* in fig. 4; and this should be brought to a point by rubbing it gently on glass paper—such as that used by joiners and cabinet makers to smooth the surface of their work. This is better than a fine file, which some draughtsmen use. For if the sand-paper be glued or gummed down to a piece of thick cardboard, or a piece of thin wood, a much more delicate manipulation of the pencil and a finer point to it are secured than by the use of the file. There is some care required to cut down and off the wood covering the lead. It is best to begin at a distance at least as great as that from *c* to *d* in fig. 4, first cutting a thin slice down on each end of the diameter of the pencil so as to make it square, thereafter rounding off the corners of this end, gradually exposing the lead, as at *a b* in same figure. The young draughtsman must not think the time lost in reading these remarks on the pencil, which he may consider as altogether too minute and particular for such a trifling matter. He will not in practice find anything trifling which has to be done, and done well; and the pencilling must be done well, otherwise the drawing will be poor and defective.

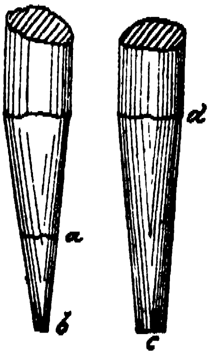


Fig. 4.

Practical Work in the Drawing of Lines the Basis of all well-executed Drawings.—Varieties of Lines.—Use of the T-square.

The young draughtsman having acquired the art of pointing his pencil fairly well—it will be some time before he becomes a proficient in it—he will now be able to proceed to his work, and this at first will be the drawing of lines. He must not think this to be mere peddling, trifling work. Although vastly easier to draw straight lines by means of his appliances than it is to draw them, as the ornamental draughtsman does, merely by the manipulative dexterity of his hand and the accuracy of his eye (see "The Ornamental Draughtsman"),—still to draw lines with quickness and uniformity of breadth, and to have the facility of stopping them exactly at any point without passing beyond it, will take some time to master so that he can do this work with facility and correct precision. It is not, however, to illustrate the method of drawing lines in various directions and of given lengths that we here direct his attention to the subject of lines. This work he will learn best and quickest to do by thoughtful and careful practice. What we wish here to explain to him is the facility with which lines can be drawn in different relation to each other, as perpendicular or parallel and the like, by the use of simple appliances now to be described. To draw lines in these relations by such appliances is a much more easy thing to do than to do them by the ordinary geometrical problems, although it is essential that the draughtsman should be acquainted with those, as he may have to apply them in circumstances where the usual drawing appliances are not available. Lines parallel to each other (see "The Geometrical Draughtsman") can be drawn through any number of given points, and at distances from each other within the compass of the paper and drawing board, with the greatest facility by means of the T-square. This has simply to be moved along either the side *a b* or *c d*, fig. 1, of the board, till the edge coincides with the point or points through which the line or lines are to be drawn. The finer the point of the pencil, as *a b*, fig. 3, the more closely can the edge of the blade of square be brought up to the point through which the line is to be drawn, and the more precisely and readily can the line be drawn to pass exactly across or through the point. If lines parallel to the sides, as *a b* or *c d*, of the board, or along the board or paper, fig. 1, have lines drawn to them at right angles or perpendicular to them (see "The Geometrical Draughtsman"), those perpendicular lines can be drawn by simply moving the T-square so that the head or stock, as *a a*, fig. 2, shall slide along one of the sides, as *a b*; the blade, *b b*, running across the board or paper. All lines drawn along the edge of the blade will be at right angles with or perpendicular to all lines drawn along the board—that is, when the head or stock of the square was used along one of the ends, as *a d*, fig. 1.

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER III.

CONTINUING the general or popular description of the indicator, begun in last paragraph of preceding chapter, and referring to fig. 1 there given, we have to state that the pencil of the "drum" *g g* being in contact with the paper on it, the result of the two motions is the tracing of an irregularly-shaped figure, which is a graphic representation of the course of the piston and the varying pressure of the steam upon it, and of which the mean pressure which it indicates is ascertained by a simple rule. The mean pressure thus obtained is used to calculate the power of the engine thus :—" Multiply the area of the piston in square inches by the mean pressure upon the piston, by twice the length of stroke, and by the number of revolutions per minute, and divide the product by 33,000." (Other rules and calculations will be given hereafter.) From the power thus obtained, the loss occasioned by friction of the various parts and by the back pressure of the steam on the piston is to be deducted—which on an average may be set down at one-fourth or one-fifth of the indicated power. By the use of the indicator the effective power of the engine is not only obtained, but by the very shape or form of the diagram which it gives we are enabled to know the condition in which it works, and the fault, if any, which it possesses.

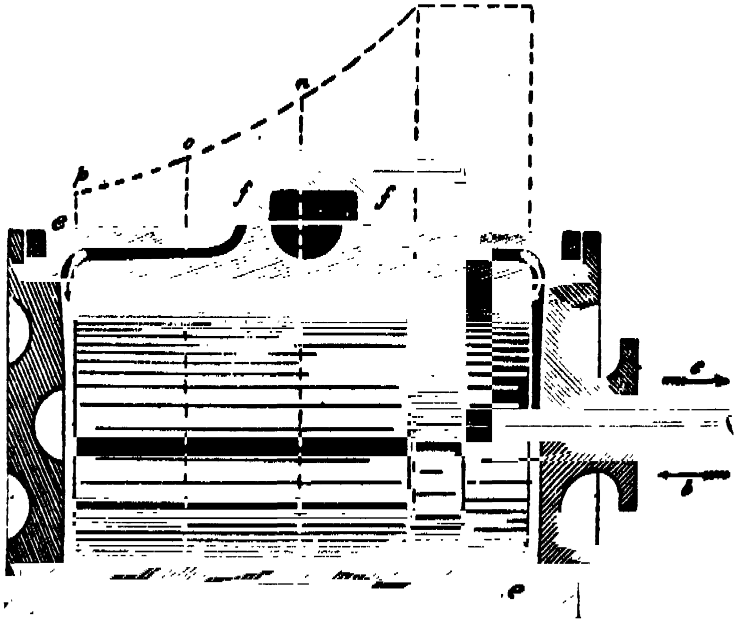


Fig. 2.

General or Popular Description of the Diagrams taken by the Indicator.—"Distribution" of the Steam in a Steam Engine Cylinder.

In order to enable the young reader to understand, in a way sufficiently clear for the present, how the indicator gives a diagram as described in preceding paragraph, it will be as well to go into a brief statement of the principle of expansive working of steam in the cylinder of the steam engine. And first it will be necessary briefly to explain what is technically termed the "distribution" of the steam in the steam-engine cylinder; and for this purpose we shall take the form in which a "three-ported" or "D valve" is used, which is technically called a "short slide."

One of the ports sends the steam to the under side, one to the upper side of the piston; the third port, which is *always* between the other two, leading to the "exhaust" tube, which passes off the waste steam to the atmosphere. The valve covers two of the ports, one of which is *always* the exhaust port. The diagram in fig. 2 illustrates the distribution of steam in a three-ported cylinder during one revolution of the crank, this being the movement of the piston, *a*, from top to bottom in a vertical, or end to end in a horizontal steam engine, as in the diagram, carrying the crank through one-half of its revolution, and then from bottom to top, carrying the crank through the other half of its revolution, and thus completing it. The points in the revolution of the crank in which it is in an exact line with the piston-rod *a a* are called its "dead points," because the piston has no influence in moving the crank round at these points, but simply a hauling tendency, as at *b*, and a pushing one at the other, as at *c*. The fly-wheel, in the momentum which it has received during the period when the piston has been giving the crank its full force, carries the crank past these dead points. The eccentric, which moves the valve, is fixed on the crank shaft, and is, in point of fact, a crank itself, changing its circular motion into a rectilineal one by means of straps and a rod, part of which is shown at *f*, the play of which is just double the distance between the true centre of the eccentric and that on which it is actually hung on the shaft. The "throw of the valve" is so arranged that when the piston *d d* is, say nearly at the top or outer end of the cylinder *e e*, as in fig. 2, the slide valve, *f f*, is at that position of its stroke when the upper or right-hand steam port is about to open, to admit the steam to the upper or outer side, *g g*, of the piston *d d*, the lower or left-hand port opening so as to allow the steam to pass from the lower part of cylinder, *d d*, *h h*, to the open air, through the "exhaust port," placed centrally between the two, or right- and left-hand ports; when the piston *d d* gets to the end of its stroke in the cylinder *e e*, the valve has been passed through half of its stroke in the opposite direction, and is just about to open the left-hand steam port, to admit steam to the under side, *h h*, *d d*, of the piston. In this arrangement the eccentric is placed at right angles to the crank, and one port opens immediately the other is closed; so that steam is admitted during the whole passage of the piston from end to end of the cylinder. This brings about a state of matters very prejudicial to the working of the engine; thus, the speed at which the piston travels varying according to the pressure of the steam from 220 up to 500 per minute, the young reader will easily perceive that at the end of its stroke the speed *must* be reduced to nothing before it can be impelled in the contrary direction—just as a man must stop or reduce his speed at the post in running before he can begin the return journey. This sudden stop may either be made by coming in contact with the cylinder end, tending to knock it out, or by pulling on the crank through the medium of the connecting rod, supposing that the piston is prevented from going to the end of the cylinder by shortening to some extent the connecting rod. This in practice is what is done, the piston in a six-horse engine being stopped within a distance of a quarter of an inch from the cylinder bottom. At the end, then, of one movement of the piston it is pulling at the crank, and at the other end pushing at it in the opposite direction, with a force due to the momentum of a speed of from 220 to 500 feet per minute. The reader will at once see how this is likely to loosen the bearings of the crank-shaft pedestal by pulling and pushing it alternately in opposite directions, and give great shocks to all the moving parts. To obviate this evil the valve is so set that the port towards which the piston is progressing is opened a little before the piston completes its stroke, so that steam is admitted to its opposite side, acting as a cushion, so to speak, and bringing it to a dead stand without any undue strain upon the connecting rod and crank. The distance which the valve is thus opened is called the "lead" of the valve, and in a six-horse engine is usually one-sixteenth of an inch. It is so called, we presume, from the valve being led so much in advance of what is its ordinary position as first described. But as the steam thus admitted to the under side of the piston before it has completed its stroke is of the same pressure as that on the upper side of the piston, the full effect of the "lead" can only be obtained by some means of reducing the back pressure on the upper or steam-pressed side of the piston; this is obtained by setting the valve so that the "exhaust port" will be opened a little before the piston has completed its stroke, thus permitting some of the steam to flow away, and release the piston of all back pressure as soon as it commences its return stroke. The distance the exhaust valve is thus opened is called the "lap" of the valve, and in a six-horse engine is nine-sixteenths of an inch.

General or Popular Description of the Diagrams taken by the Indicator.—Expansive Working of Steam.—Form of the Indicator Diagram.

But in addition to the disadvantages named in preceding paragraph, arising from the system of admitting steam at its full pressure to follow and press upon the piston during its whole stroke, another, and a great one, is in the waste of power incurred by it. Let us see how this arises. Steam is a highly elastic fluid, and, like all elastic fluids, is capable of being compressed and expanded in volume. By compressing it into a less space we increase its pressure and decrease its volume; by expansion we decrease its pressure and increase its volume. Mariotte was the first to show that the "pressure is inversely as the volume": so that if we compress an elastic fluid into half its bulk we double its elasticity or pressure upon the vessel which contains it; conversely, if we allow it to expand into a space twice its usual bulk we decrease its pressure one-half. Now, by this law, with a gradually increasing expansion we have a gradually decreasing pressure; so that if we admit steam to press a piston till it reaches half its stroke, and then cut off the steam, admitting no more, the piston moves on, thus increasing the space into which the steam expands, decreasing the pressure till the piston, reaching the end of its stroke, gives the greatest amount of expansion and receives the minimum amount of its pressure. This is what is meant by the "expansion of steam," and the point at which the port is closed by the valve is called its "cut-off." This may be at one-half, but usually it is one-third or one-fourth of its stroke. Though there is evidently and in fact a loss of power by working expansively, there is a great saving of steam. Thus, taking the cylinder of a high-pressure six-horse-power engine at 7½ inches diameter and 14 inches stroke, and using steam at 50 lb. of pressure, during the whole of the stroke we have a power obtained equal to 240 lb., with an expenditure of 59 cubic inches of steam; but by cutting off the steam at one-fourth of its stroke, we have the power measured now at 147 lb.—a great loss apparently; but then we get this with the expenditure of a fourth part of the steam (14¾ cubic inches), which is a very great saving. In round numbers we may assume that we get 2¼ times the work by using steam expansively. Let us explain how this is brought about by the use of a simple diagram. Let *h h g g* (fig. 2 *ante*), represent the outline of a cylinder of a six-horse high-pressure engine, the diameter of which is 7½ and stroke 14 inches. The pressure of the steam employed is 50 lb., and the admission of the steam to the cylinder is cut off at one-fourth of the stroke of the piston. From the point *g* to *i* the pressure is kept up to 50 lb. Cut off at this point, the steam begins to expand into the space formed by the passage of the piston, till, on reaching the point *j*, or one-half of its stroke, the steam has expanded to twice its bulk; and in virtue of the law already explained, its pressure is reduced one-half, or to 25 lb. On the piston reaching the point *k*, or three-fourths of its stroke, the steam is expanded to three times its bulk, and the pressure reduced to 16⅔ lb. Moving still onwards, it reaches the end of its stroke at *h*, and the steam, expanded to four times its bulk, is reduced to one-fourth of the original pressure, or 12½ lb. The mean of these pressures gives a reduced pressure, but at an expenditure of a quantity of steam filling one-fourth only of the cylinder, from *g* to *i*.

In the last paragraph but one we showed how the indicator gave a pencilled diagram on the paper wrapped round the drum *g g* (fig. 1): we are now in a position to explain the general form and value of an "indicator diagram" by the help of the illustration last given (fig. 2 *ante*), and the preceding remarks on expansive working.

The line from *g* to *e* represents the rise from the atmospheric pressure existing in the cylinder at starting up to 50 lb., which is the assumed pressure of the steam admitted to the cylinder, the line from *l* to *m* the continuance of that pressure during one-fourth of its stroke. The gradually curved line formed by joining the points *m*, *n*, *o* and *p* shows the gradually decreasing pressure in the piston as it goes on to the end of its stroke. From *m* to *h*, upper left-hand side of diagram, indicates the fall of the pressure from that point *m* to the upper line *g h*, which is called the "atmospheric line." This would make a perfect diagram, but modifications in its form are brought about by defective working of the engine. In all diagrams the corners are rounded off more or less, owing to the gradual introduction of the steam into and its gradual exhaust from the cylinder; while all these are exaggerated by defective setting of the valve. Certain defects so indicate themselves by certain forms of the diagram, that they are reflected in it, so to speak, almost as accurately as the reflection of an object is given in a mirror, and consequently the engineer knows how to remedy them.

General Principle of the Indicator.

The indicator may be considered as virtually a small steam engine, except that it has not the power to give motion, nor is it required to work any machine. The steam and vacuum which are in the main cylinder of the engine are of precisely the same value in the indicator as in the engine. Whatever is the result or force of steam, etc., in the engine cylinder, it is, so to say, photographed on the paper of the indicator. Photography is now so thoroughly understood that we hope the allusion to it may be pardoned; and it will undoubtedly picture to the mind of the reader a method of reading off and understanding the result of the figure or diagram transferred to paper, which thus becomes a facsimile of what is at work in the interior of the large or main cylinder of the steam engine, from which all the results of power proceed. Having a clear idea how things are conveyed, though somewhat mysterious, one will more readily understand what is the nature of the work the indicator does.

Perhaps some of our young readers may have heard of two kinds of steam engines, and therefore they may be a little perplexed, and wonder which of the two we are alluding to in connection with their indications. It is, of course, necessary that the difference between the two engines should be generally described, so that every matter in connection with the steam engine indicator may be clearly understood. Two classes of engines are in use; and we give a brief description of the two so far as the difference between them is concerned. One kind is known as the "condensing engine," the other as a "high-pressure engine." Both, of course, are worked by steam. The condensing engine is invariably supplied by steam of a much lower pressure.

A low-pressure engine, or a condensing one, are one and the same. The condensing engine receives its name from the circumstance of the steam being condensed as soon as it leaves the cylinder. This is done in another cylinder called a "condenser."

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER VI.

CONTINUING our description of the "points" of the "Hereford" breed of cattle, we go on to state that if in good condition, and when "full-coated"—that is, with the hair fully grown—the body colour of the bright red is mottled or dappled with tones or shades of a deeper red. Any white on the animal is considered a sign of defective breed. A white udder in a cow may be overlooked, if the only part of this colour, but it would be rather missed than possessed by fastidious breeders. The eye is large and prominent, and gives a marked degree of placidity to the expression of the face; the nose is small, and the horns are elegant, in curved contour. As we have said, the carriage of the animal is fine, and the whole frame is very symmetrical. The bosom is full, with a deep chest; the legs are small, tapering, and fine in bone below the knee; and where the fore-legs begin to swell out at the upper part, they suddenly lose themselves in or become merged into the shoulder. The back is straight from the withers to the rump. The withers are light, and rest on or spring from the shoulders, which slightly retires and spreads, and well rounded below. The hind-quarters are high and fleshy. The meat or flesh is well laid on the shoulder points, fore-flanks and sides; and combined with what is a particularly favourable point in the breed, the peculiarity to lay on flesh along their tops, make the breed an almost perfect one as a meat-producing animal.

Classification of Fattening Cattle according to the Form or Kind of their Horns.

Cattle are by some classed according to the length or general character of the horns by which they are distinguished. Mongrel or cross-breeds are not distinguished by this point any more than by any other of the points by which "breed" is known. The influence of a multiplicity of "crosses" purposelessly or carelessly carried out, bring into existence all varieties of characteristics in form, colour, and feeding qualities. The influence of the first cross, or of any marked cross at any subsequent period, where the cross has been with a pure-bred animal or one approaching to anything like purity of breed, lasts a long time—much longer than many would be disposed to think, so powerful is the character impressed upon an animal by a good breed. And of all the points which remain longest in their influence the horns may be perhaps taken as that point which is the most marked. However this may be, it is only to be noticed here that the mongrel, or carelessly and repeatedly crossed breeds, show a wide variety of horns, although but few comparatively are distinguished by very long horns,—generally they vary between what are decidedly short and those which are medium. Classifying what are called the true breeds of British cattle according to their horns, we find that they all come under one or other of three classes or divisions: first the long-horned breed, second the middle-horned, and third the short-horned. And these three classes take in the cattle of the three kingdoms—England, Scotland, and Ireland. Some writers treat of cattle under the national divisions, as English, Scotch, and Irish, without taking into account or classing them according to the length of their horns; the hornless breeds, known generally as polled breeds, falling to be described, under this national division, promiscuously along with the horned breeds. We shall describe the polled breeds in future paragraphs, as forming—as their remarkable peculiarity naturally forms—a distinct and special class.

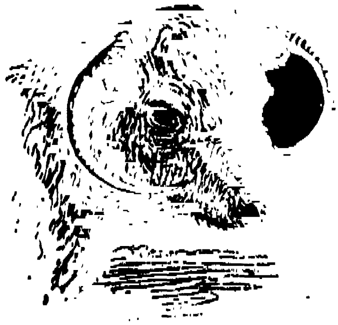


Fig. 4.

The Long-horned Breed of Cattle, or "the Longhorns."

This breed takes its name—as will be obvious, from the illustrations given in figs. 4 and 5—from the length of the horns. These vary in regard to the curve or contour, but the form in the head in fig. 4 may be perhaps taken as the most characteristic shape in the

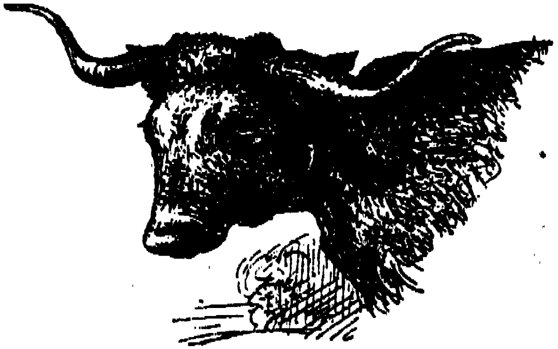


Fig. 5.

best animals or purest in breed—at least most common in the breed, bending inward and downward and partly upward in a line with the cheeks. In other cases, as in fig. 5, the horns spread out widely from and in a line with the head, sometimes nearly straight, sometimes turning outwards from the head, but with points turned upwards. The length of the horns is greater in oxen than in the bull; sometimes they reach in the former to a length of 42 in.; from this down to 30 to 32 in.; in the bull from 24 in. down to 15 in. and 16 in. In the cows of the breed the horns are about as long as those of oxen or fattening cattle, but are much finer and generally taper off to fine points. Different breeders have different tastes in the matter of the form or contour of the horns, a difference in this respect, if it meets the wishes of the purchaser, bringing often a much higher price than in an animal not possessing the horn peculiarity desired. Fig. 4 gives a variety of disposition of horn which is much admired by some, and is in fact the characteristic of a very distinguished herd of the breed.

The breed of longhorns—at one time known as the Craven, sometimes the Leicestershire breed—has been known, from times the most remote in our national history, as the breed of the north of England. The localities of the breed comprised a very wide extent of country, taking in parts of Yorkshire—of which the Craven district is the most distinguished in the annals of the breed—part of the counties of Westmoreland, Lancashire, and Cheshire, parts of Derbyshire, Staffordshire, Shropshire, Warwick, and of Leicester, Worcester and Northampton. Although the breed is now admitted to be a hardy one, and does excellently well in districts of which the pasturage can have no claim to be considered as first-class in quality, yet in the earlier days of the history of the breed it was considered essential to have pasturages of the highest character. Hence districts in which such were found, as those bordering the rivers Trent and the Dove in the midland counties, gave the finest examples of the breed.

The Longhorn Breed continued.

For a long time the breed had no particular attention paid to it in order to improve its natural qualities; these generally were a disposition to grow fat on fine pasturage, and to keep in fair condition when this was not so good, being on the whole considered hardy; the beef was of good quality, and the hide for certain reasons was held in greater esteem by tanners than the hides of most oxen. But the breed took no very particular place as a fine one till about the middle of last century, when the celebrated breeder Robert Bakewell, of Dichley—often in farming works and by many breeders spelt Dishley—near Loughborough, in Leicestershire, took the breed in hand. Bakewell may be said to be, and in view of other competitors for the honour was truly, the father of modern farm live stock breeding. He was assuredly the first to raise it to the dignity of a science, having fixed and definite principles upon which its practice was based. Bakewell was perhaps most celebrated, as by many he is better and by a few only known, as a breeder of sheep—the celebrated "Dichley breed" being known to all acquainted with the history of this class of animals of the farm. As will have been observed, from what was incidentally stated in a former paragraph, Bakewell was well aware of the shorthorn breed and of its value, but for reasons of his own he preferred to take the longhorn in hand as that on which and by which he was to carry out his well-thought-out views on breeding. The stock which as the Dichley herd ultimately became so celebrated, started from a cow of the Cowley breed crossed by a bull from Westmoreland, selected and purchased by Bakewell. This "Cowley" breed took its name from a village of the same name near Coventry, in Warwickshire, at which farmed a Mr. Webster; who had brought some cows of the long-horned breed from the banks of the Trent, to which we have already alluded as a favourite place for feeding good animals of the breed. Those Trent cows had been got from a breed known as Sir Thomas Glasby's, which had originally come partly from Westmoreland and partly from Lancashire. With the cross of the Cowley cow with his selected Westmoreland bull, Bakewell got his bull "Twopenny," afterwards so celebrated. Applying all his profound knowledge of and skill in breeding and management, acquired chiefly in the making of his celebrated flocks of sheep, and by years of quiet and close observation and patient trials, Bakewell in a comparatively short time established for his herd of longhorns a high reputation, and reaped both fame and profit from it. Previous to Bakewell's labours in this wide field of productive work, other breeders had succeeded in giving to certain animals or small herds breeding qualities of considerable value; but this was done, and considered possible only to be done, where the cattle were fed on the finest pasturages obtainable. It was reserved for Bakewell to show that he could obtain a breed with the desirable qualities even when the land on which they were bred was not of the finest. The following is a description of the points of the breed, from the pen of an able authority.

"The fore-end long, but light, to a degree of elegance; the neck thin; the chap small and clean; the head fine, but long and tapering; the eyes large, bright, and prominent; the horns varying with the sex: those of the bull comparatively short—from fifteen inches to two feet; those of oxen from two feet six inches to three feet six inches; those of the cows nearly as long, but much smaller, tapering to delicately fine points." The horns are variously disposed, sometimes taking a direction wide spreading in a straight line from the head; sometimes inclining forwards with the points turning upwards; but the most common direction is that of bending upwards and downwards, in a line with the cheek, the points more or less approaching each other, sometimes crossing the nose, or bending under the throat. Many of these peculiarities have by turns been considered as the most beautiful, and have frequently made the difference of between three and four guineas in the value of the animal. "The shoulder remarkably thin and fine; in respect of bone, thickly covered with flesh; the girth small, compared with the short and middle horned breed; the chine remarkably full when fat, but hollow when low in condition; the loin broad; the hips remarkably wide; the quarters long and level; the neck of middle width; tail set on variously; the round bone small; thighs fleshy, but tapering towards the gambrels; the legs small and clean, but comparatively long; the foot neat, and of a middle size; the carcase as nearly a cylinder as the natural form of the animal will allow; the ribs standing out bold from the spine, and receiving the entrails within them; the belly, of course, appears small."

It may appear strange to some readers, after all we have said in preceding paragraphs as to the high value of the "shorthorn" breed of cattle, that Bakewell should, although he knew of it, have passed it by, and taken to a breed which has not sustained, and indeed never obtained, the high position which he believed he could secure for it. But it is generally understood—and the belief is based upon the best authority—that Bakewell deliberately chose the longhorn as the one to form a herd from, because he was strongly convinced that there was no other breed that he knew of, the animals of which could keep themselves in such good condition upon so little food. And this belief is maintained by many still. At present the breed is rising in reputation, and of late years it has had a separate class given to it at some of our agricultural shows. The following gives the dimensions of a well known bull of this breed:—Length, from the rump to the extremity of the hip bone, 2 feet 4 inches; from the poll to the tail, 7 feet 6 inches; of face, 19 inches; of horn, 25½ inches.—Height, from the ground to the brisket, 19¼ inches; chest, 24 inches; of the hind-quarters, 4 feet 8½ inches; shoulder, 4 feet 7 inches; knee, 13½ inches; hock, 17 inches.—Breadth, across the eyes or forehead, 10½ inches; of the hips, 2 feet.—Girth, round the "chap," 1 foot 9¼ inches; cheek and forehead, 3 feet 9 inches; neck, 3 feet 7 inches; chest, 6 feet 11 inches; knee, 14¼ inches; horn, 9½ inches at root; bone of fore-leg, 8½ inches; coronet of fore-foot, 14 inches; bone of hind-leg, 9½ inches; coronet of hind-foot, 11 inches.

The West Highland Breed.

Following the classification of many writers who take the British breeds according to their country, as England and Wales, Scotland and Ireland, this breed would not fall to be noticed at this point. But as we are not giving an exhaustive description of all, but only of the leading breeds; and as we have—after describing the shorthorn as the chief of all the breeds—classified the others according to their horns or the absence of them, we come next to the "West Highland ox" of the Scottish breeds, as an example of the long-horned animals. Curiously enough, this has by some writers been distinguished as a middle-horn breed. This may be, and is, in many cases, its characteristic, if a cross with the shorthorn; but one mark of the pure breed is its "noble branching horns." The West Highland breed is not so great a favourite as it once was; although its flesh is still highly esteemed by West-end butchers, the best judges of what suits the public taste; still there is, notwithstanding, an extensive rearing of the breed, and its deportation, and also its carriage as "dead meat" to the southern grazing districts and markets, constitutes a large part of the business of the Scottish grazier—by whom, and indeed also by his southern brother feeder, the breed is often called "black cattle"—or as in the south frequently the black Scotch, or in its inverted form of Scotch black. The breed possesses many valuable characteristics entitling it to the notice of the grazier and butcher: the quality of the meat, the hardiness of the breed, and the poor or comparatively poor pastures from which it contrives to produce this meat, as on the hilly or upland districts of the southern parts of the kingdom, or in any district where the pastures are poor; and finally, the readiness with which it lends itself to the system of cross-breeding—all combine to make the breed one well worthy of the consideration of the grazier. And as a fine, indeed an attractive if not a distinguished-looking animal, it possesses claims of no mean order. And taking the breeder's estimate alone of it, it is worthy of notice that it has many of the points characteristic of the pure-bred shorthorn, as will be seen in the description of the points of the breed given below. The West Highland breed is the original breed of the west and of a large part of the north of Scotland. At one time, before the great fortunes made chiefly by English merchants and manufacturers tempted by high rents the "Highland lairds" to change their system of pastoral lands into "deer forests"—which was one cause; and before the change of the system of farming *per se* substituted, and so extensively, sheep for cattle breeding and rearing—which was the second cause; the black cattle were seen in numerous herds scattered nearly all over the hill-pastures of the north of Scotland.

THE COLOUR MANUFACTURER.

WITH PRACTICAL NOTES ON THE USE OF PAINTS AND DYES IN DECORATIVE WORK.

PART FIRST.—PIGMENTS.

CHAPTER III.

In continuation of the subject of the objections to the use of white lead as a pigment, we have further to observe that when taken either into the stomach or through the pores of the skin, it exerts powerful poisonous properties. Plumbers' colic is a well-known trade affection due to white lead entering the system through the skin. It may here be mentioned that the usual remedy is very dilute vitriol—which it need hardly be said must not be taken except in extremely small and cautious doses. Recently a patent has been secured by Messrs. J. B. Freeman & Co., of Grove Works, Battersea, London, for a "non-poisonous white lead paint," to which we shall have occasion to refer hereafter.

Zinc White or French White.

This valuable pigment is oxide of zinc. It is equal in whiteness with white lead, but is wanting in density or body. It has an advantage over the latter pigment in being unacted upon by sulphur fumes and coal gas. It is also more permanent than white lead; it is not acted on by oil as the latter substance is, and consequently it keeps its brilliance and solidity for years, whilst white lead, under similar circumstances, loses in depth of colour in as many months, and becomes semi-transparent, permitting the colour of the surface beneath it to be plainly seen. This latter property of white lead is due to the decomposition of the oil used with the paint: a fatty acid is formed, which slowly acts upon the carbonate of lead, forming a lead soap or lead plaster, and giving off carbonic acid. Such a reaction does not take place in the case of zinc white, no zinc soap being formed.

Manufacture of Zinc Oxide White.

The manufacture of oxide of zinc or zinc white is carried on in a long furnace containing a double row or series of bottle-shaped clay crucibles or retorts, which lie in a reverberatory furnace—the mouths of which open through the wall or side of the furnace, into a long passage connected with wide pipes for leading the vapour away. The retorts, which are of fire-clay, generally measure 28 or 30 inches in length, 10 inches in breadth, and 6 inches in diameter or depth, the diameter at the mouth being about 2½ or 3 inches. The vapour passage is supplied with hot air obtained by the waste heat of the furnace. To charge the retorts the mode of procedure is as follows. The furnace is raised to a high temperature, so as to bring the retorts to a bright red heat. Bars of metallic zinc are then projected into each retort, through the open mouths or ends of the retorts, through sliding doors in the vapour passage. These doors are then closed, the furnace raised to a strong heat; the metal fuses, boils, rises in vapour and rushes out of the mouths of the retorts into the vapour passage, where, coming in contact with the current of hot air, it takes fire and burns into the white oxide, which is carried by the current along wide conducting pipes into collecting chambers, where it accumulates on the sides and is removed through sliding doors. Each retort of the size above named communicates with four collecting chambers—which are of the form of large bottles inverted, the vapour pipe passing into the first chamber at the top, which opens into the second chamber at the bottom, which again opens into the third at the top, which opens into the next at the bottom. It is evident from this that any heavy particles carried over from the furnace or more readily condensible matters, will collect in the first chamber. That portion of the zinc oxide which collects in the first chamber is of a greyish colour, due to the impurities present in the metal, and to particles of unburnt zinc. This first portion, therefore, is collected, and forms a zinc white of inferior quality; the oxide which, having escaped collection in the first chamber, passes over into the second, third, and fourth, forms white of better quality.

Testing Zinc White Oxide.

Baryta white and gypsum are detected in the manner described under white lead. Chalk, or carbonate of lime, is detected by dissolving the sample of zinc white in dilute hydrochloric acid, adding ammonia in excess, and then ammonium oxalate; when, if lime be present, an immediate white crystalline precipitate will form, which completely dissolves in dilute hydrochloric acid and re-forms on adding ammonia. Chalk may also be detected by treating the sample with dilute sulphuric acid; the zinc oxide alone dissolves, whilst any chalk present is converted into the insoluble sulphate of lime with effervescence.

Sulphide Zinc White.

Under the name of Griffiths' zinc white is sold a white pigment which appears to possess more body and solidity than the ordinary zinc white, and is equal to it in whiteness. The mode of preparation of this pigment is as follows. A mixture of sulphate or chloride of zinc and sulphate of magnesium (or Epsom salts) is prepared, and to it a slightly alkaline solution of sodium or ammonium sulphide is added. A copious white precipitate forms, which is collected, heated in a reverberatory furnace, and suddenly cooled. The product is a pigment of pure whiteness, which is then ground in a mill and is ready for the market.

Manufacture of Baryta White.

Baryta white, or sulphate of barium, is a pigment which is chiefly used in mixing, or obtaining shades, "reductions" or pale colours. As a white it is not extensively employed, owing to its lack of that "body" so essential to form a good white paint, and which is possessed in so high a degree by white lead. It is, however, somewhat largely used in *distemper* paint, its defect in respect of body being in this class of work not so conspicuous. It occurs in a native state as heavy spar, and may be made artificially; it occurs as a by-product in the manufacture of mordants, for dyeing from acetate of baryta and sulphate of alumina, etc.

The native product is prepared for use by grinding with water to a very fine paste; the quality obtained is inferior to that obtained artificially, being slightly coloured by impurities, and being moreover in a less fine state of division. It is a cheap material, cheaper than the artificial product, and cannot as a rule be employed for fine paints.

Gypsum.

This well known compound, known also under the name of plaster of Paris—the great capital being the first city to draw much attention to its use as a material in construction—is a hydrated sulphate of calcium or lime, the formula being $CaSO_4 + 2H_2O$. It is found very plentifully, chiefly in strata of the tertiary formation. The use of gypsum as a mortar, etc., depends upon a remarkable property which it possesses. When it is dried at a temperature of 132° C. it loses nearly all its water, and is then termed burnt gypsum, or spar lime, which is the material used in making stucco work, and contains about 5 per cent. of water. When this is mixed into a paste with water and allowed to stand, it sets hard, owing to the union of the water with the burnt gypsum, forming $CaSO_4 + 2\,H_2O$. When ordinary unburnt gypsum is treated with a dilute solution of sulphate or carbonate of potash it quickly hardens on standing, the compound $CaSO_4 + H_2O$ being formed. Sulphate of lime is largely used for "enamelling" paper, for which purpose the product obtained by precipitation is found to be the best.

Whiting or Chalk.

This article, so largely employed as a friction cleansing agent, and as common marking chalk, is not used in oil painting, but finds rather extensive employment in distemper work. Chalk, or carbonate of lime, is represented by the formula $CaCO_3$; hence in contact with acid, such even as vinegar, it gives off carbonic acid gas and loses its whiteness. It is prepared for use in distemper either by finely powdering the native chalk or by precipitating a soluble salt of lime, such as the chloride, with carbonate of soda, filtering, washing, and drying the pure white precipitate. By the latter method it is possible to obtain a whiter product than the generality of natural chalks. Chalk is largely used in chemical manufacturing, as a source both of lime and of carbonic acid. When strongly burnt, chalk is converted into common lime; but for the manufacture of this material limestone is used, a substance of the same composition as chalk.

China Clay.

This important compound is used in immense quantities in the porcelain and pottery industries, and in "finishing" cotton goods. It is a silicate of alumina. It is a pure white, completely insoluble, very heavy compound, found in extensive beds in Cornwall and many other parts of England.

Sulphate of Lead.

Sulphate of lead occurs, as stated before, as a by-product. It is also obtained by precipitating a soluble salt of lead with dilute vitriol. It is used to some extent in painting, especially for mixing with other whites to cheapen them. It is a very heavy pigment, but does not form so good a white pigment for painting as white lead. Its formula is $PbSO_4$.

List of the Chief Whites used in Water-Colour Painting.

We now append the chief whites in use in water-colour painting, and known by fancy or arbitrary names.

Spanish White consists of the finest white chalk, free from impurities of sand, iron, etc., and finely ground, washed, collected, balled or caked, and carefully dried ready for the market.

Wilkinson's White.—This is an impure oxy-chloride of lead, obtained by grinding litharge with sea-water until perfectly white. The product, after thorough elutriation and washing by decantation, is collected on a filter, dried, finely ground, and again dried.

Lead Sulphate White.—This is simply sulphate of lead, obtained by precipitation of sugar of lead by sulphate of soda or dilute vitriol.

Chinese White.—The pigment sold under this name generally consists of a paste obtained by rubbing, by small portions at a time, fine zinc white with gum tragacanth mucilage until of even consistence and of the desired strength. The latter paste is obtained by steeping 1 lb. of best transparent gum tragacanth or gum dragon, broken in very small pieces, in 1 gallon of cold water for twelve hours, then boiling with constant stirring for about ½ to 1 hour, or until of even consistence. The paste obtained is strained or forced through calico, to remove lumps, and is ready for mixing the pigment. This pigment is very largely used in water-colour painting, being easily workable along with nearly all other pigments.

Permanent White.—This is the sulphate of barium obtained by precipitation from chloride of baryta with dilute sulphuric acid or sulphate of soda, the latter being preferable.

Alum White.—This pigment, which is used for special purposes, is composed chiefly of the hard insoluble oxide of aluminium or alumina. It is prepared by mixing 1 lb. of powdered alum with 6 oz. of honey into a smooth paste, then drying and calcining until all the black charcoal is burnt and the mixture is perfectly white; after which it is washed and dried.

Pigment Reds in Common Use.

The pigment red colours in common use may be enumerated as follows: (1) red lead or minium, by far the most extensively used pigment; (2) red chromate of lead, which we will treat under the head of chrome yellow, as it is more of an orange than a red. (3) Red ochre; and (4) English rouge, which we will treat under the head of iron yellow ochre; (5) vermilion, the prince of pigments, largely used in fabric printing, but too expensive for common use; (6) mock vermilion, or antimony vermilion; (7) mineral kermes, also an antimony pigment; (8) madder lake, much used in fine painting for obtaining delicate rose tints; (9) Brazil-wood lake, used for the same purposes as the last mentioned, but not so permanent; (10) carmine, or cochineal lake, a magnificent lake obtained from the cochineal insect dye, and extensively used in fine painting (other red lake we shall have occasion to refer to); (11) Rose pigment, of pink colour, used in distemper and in paper staining; (12) Realgar, or bisulphide of arsenic, and a few other red pigments of less importance than the above named, and to which we will briefly refer.

Red Lead.

Red lead, or minium, is manufactured in large quantities, being mostly consumed for the painting of iron and wood work. For fine painting it is not well adapted, for the same reason that debars white lead from a similar employment—namely, its property of blackening in contact with foul and sulphurous fumes. Red lead is an oxide, or strictly speaking a mixture of the two oxides of lead, litharge or protoxide and brown dioxide. It may be represented by the formula Pb_3O_4, although strictly speaking it should be represented as variable mixtures of PbO and PbO_2.

The manufacture of red lead is conducted after the following principle. Metallic lead—which should be as free as possible from antimony, silver, and even iron—is melted upon the surface of a broad, rather low reverberatory furnace, and kept in a state of fusion during forty to fifty hours; the liquid is raked at intervals, and a good draught of air plays upon the surface of the molten metal. This treatment completely converts the metal into the red oxide. When the correct tint or shade of red is obtained, the top and front portions of the contents of the furnace are carefully raked out and fresh charge put in.

Vermilio

This magnificent pigment is of a brilliant scarlet colour. It is a sulphide of mercury, and hence is costly, and finds its chief use in the calico printing industry. No pigment probably requires so great care in its manufacture as this one, upon which almost wholly depends its quality. It is of the identical chemical composition as the black sulphide of mercury, both substances being represented by the formula HgS. On adding sulphuretted hydrogen gradually to a mercuric salt, a white precipitate is first formed, then an orange, and finally a black precipitate, which by careful sublimation is converted into brilliant scarlet. Vermilion is manufactured in two different ways—the wet and the dry methods.

The "Wet" Method of making Vermilion.

24 lb. of pure sublimed sulphur are placed in a mill, and mixed into a smooth paste with 6 lb. of caustic potash dissolved in a little water; 105½ lb. of mercury are then added, and the mixture is ground together until homogeneous or of even consistence; 50½ lb. of caustic potash dissolved in 5 gallons of water are then added, by small portions at a time, and with agitation of the mixture. The mixture is next slowly ground up again for a short time, and is then transferred to a crucible and cautiously heated on a sand bath with constant stirring the whole time, the water lost by evaporation being from time to time replaced. No rules can be given as to the amount of heat required, nor as to what exact temperature the mixture ought to attain, these being points which are decided by the appearance of the mass as the heat rises, which causes the mixture gradually to thicken and become scarlet red. It is necessary to increase the temperature very cautiously, and to take the crucible from the sand bath at a certain stage, which experience alone can teach, when the pigment reaches its greatest brilliance of colour. This being done, warm water is added, the mixture being continuously stirred, until the temperature of the mass sinks to about 120 F., when a solution of caustic soda at the same temperature is added, and the whole allowed to settle. The supernatant liquor is then poured off, and the vermilion is thoroughly washed with cold dilute solution of caustic soda, and finally with pure water, after which it is very carefully dried and very finely ground in a mill. The details of the manufacture of vermilion are not known except by the few makers themselves; many points, apparently trivial, such as the rate of heating as well as the degree of heat, having considerable effect on the finished product. It is of vital importance to employ only materials of the purest kind; the sulphur should be perfectly pure, and the caustic alkali free from iron and from any quantity of alumina.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER VI.

"Energy Exerted" and "Work Done," may be considered as Synonymous or Convertible Terms.

WE now see how "energy" may be said to be "work"; and for all *practical purposes* this is emphatically true. We thus arrive at a more extended definition of the term, which we may put in this form: Energy is that manifestation or development of force by which work is done. The work which is *done* is practically the measure of the force which has been manifested or developed. Energy, therefore, is simply the putting forth of the force which one naturally possesses to the performance of a certain "duty" or "work," and has practically no existence till this manifestation or development takes place. We may actually possess the force necessary to drive a wedge into the cleft of a rock, but we give no proof that we possess it till we put it forth or develop it, so that we positively drive the wedge into the cleft. When the work is thus done we can then, but only then, say that "energy" has been shown or developed.

General Sources of Energy.

We have employed the human body as an illustration of the force which exists, and which can be developed into the doing of "work," or giving out what, in another mechanical phrase, is termed "duty." But it is obvious that all we have said applies equally to any other body in which force exists—as a steam engine. And although that may be such as that of a certain number of horses, this can only be practically proved or demonstrated by the "work" being actually done, or, as we often express it, the energy shown. The sources of force, considering it mechanically as a distinct entity, or as a something which can be practically taken hold of or availed of, are various, such as that obtained from steam (this primarily being derived from the combustion of coal), from water, wind, and that source of which we now hear so much — electricity. All these are called "sources of energy"—or, to carry out the train of thought we have already expounded, we may call them sources of a "power for the doing of work." These are made available, or means are given to man by which he can draw practically upon them, so that they will do his "work"—*i.e.* expend their "energy"—by contrivances which are generally and popularly described as mechanical. We thus arrive, following up the considerations we have adduced, at a definition of the term "machine,"—a combination of parts known generally as mechanical, by which "energy" is transmitted "from one point to another." Thus, in the case of the cleaving of wood, formerly named as an example of "work" done, we have the force existing, no matter how, in the body, given out as energy by the arm, and this acting as a lever, and the hand as the "gripping," "nipping," or "holding" capability or power of the axe handle, transmits the human "energy" to the axe edge which cleaves the wood—as in the work of the cotton factory the energy of the steam-engine is transmitted to the point at which, say, the work of "carding" is actually done through the agency of the combination of mechanical parts to which the name of the "carding engine or machine" is given. In this train we have at one end the source of the energy, at the other the work which is to be done, and between them the intermediary by which the primal energy is laid out in the actual doing of the work. And in proportion to the requirements of this work and its nature, the intermediary or machine varies in principle, form, and complication of construction. When we talk of a man who is doing his work well, we have seen that we generally apply the term "energetic" to him. When we see a machine performing its work with ease we do not apply this term, but we say that it is "powerful," or "effective," or that it is efficient.

Power in Doing Work as the Result of Energy.

Energy has been and is often defined as "internal or inherent power," or "power apparently and forcibly exerted." Bearing in mind what has been in preceding paragraphs stated on the subject of force, it will be seen that the term "power" is taken as synonymous with "force." This is exemplified in many directions; but specially and in close connection with our subject we may cite two expressions much in use amongst mechanics. Thus, when we say that a steam engine "exerts a force of two hundred horses," or that it is "of the power of two hundred horses," we mean precisely the same thing. And we have seen that "force" *per se*, that is, considered by itself alone, may exist in a body, but may practically, so far as work is done by it, be said not to exist at all till it is manifested or developed, which development is known as "energy"; so that the definition of energy given above—namely, that it is "inherent or internal power"—is practically correct. The definition of a machine as given at the close of the last paragraph may therefore be so far altered that it will accord with ideas which are almost invariably prevalent amongst working mechanics. In this way it will stand thus: a machine is an arrangement of mechanical parts for the transmission, the distribution, and the direct application of "power for the doing of work."

Definition of the Terms "Power" and "Strength."—Practical Points connected with them.

In accordance with our system of seeing what conception of the true meaning of a word may be obtained from tracing it to its "root" or its "derivation," we may here look a little closely at this term "power," which in the mechanical world is very much better known, or at least much more frequently used in daily talk, than its equivalent—"energy." The word power is derived directly, that is, with the least degree of change in its written or spelt form, from the French *pouvoir*, meaning "to be able." This is derived from the Latin *posse*, which also means the same thing; and this, again, has its root in the Latin words *potis*, which means able or capable, and *esse*, to be. Power, therefore, means ability to do, to act; and doing or acting in the mechanical sense of the term is "work done" or "duty performed." When, therefore, we say that a steam engine, for example, is of two hundred horse power, we mean practically and mechanically that it is able to do a work equivalent to that which the "strength" of two hundred horses would suffice to do. A word is here introduced, which we have placed in inverted commas, that is very frequently used in mechanics; and we thus see how it comes, as it were, out of the term "power." We talk of a framework, for example, as being of a certain strength—by this meaning that it has the "power" to resist that something which would tend to break it down, disrupt its parts, or, in other words, render it useless for the purpose of supporting the weight or resisting the pressure for which it was designed. In like manner, when we say that the "strength of a machine lies in its weakest part," we know that it is meant by this that the weakest point will define the capability of the machine to resist influences which would render it useless for doing the work for which it was constructed. The word "strong" itself—"strength" being, as we have just seen, the quality of being strong—is Anglo-Saxon in its origin, its root being the German *streng* or Icelandic *strangr*, and means having the physical capability or power to act or to resist. Finally, in connection with the meaning of the term "power," we must remind the reader of that which carries with it a great amount of suggestive matter if he will but think it over—that the term or word "possible," so often in the minds of many, has the same root as power, namely, *potis*; the Latin word *possibilis*, our word being but slightly changed from this, means "capable of being done."

Natural or Practical Sources of Force or "Power."

We have hitherto considered the source of force as being derived from the human body, or what is called its muscular power or force of muscle. This would be of necessity the first source of it with which man would become acquainted. But it would not be long before he would find out that there were other sources of this mysterious "something" which displayed itself so often in his daily life, outside of or exterior to himself. Possibly the first of those external sources of force he would discover by analogy or a rough mode of reasoning, but much more probably by some painful accident, would be the force the muscular power of animals, such as a kick from a horse, would exert. But, going still further afield, he would soon learn that there were other sources of this "something," by whatever name he would then call it. For example, he would soon learn that the something we call "wind," which would at one time scarcely blow the tangled hair from off his brow, could at another blow himself over, or at another blow away the rough hut he had raised to shelter himself from the tender mercies of the weather, and even to uproot and blow over great trees. So in like manner he would find out that water possessed the power or capability of giving out this "something," or force—as for example if he passed under a waterfall heedlessly, or saw the rivulet beside his hut at one time flowing with such feeble force that it scarcely bent the lily stalks or swayed their leaves to and fro, and at another with so much vehemence that it swept everything before it, even his hut itself.

Centuries of Patient Observation, Investigation, and Work, required before Man could, as now, avail himself of the Natural Sources of "Energy" or "Power."—Water Power.—The Water-wheel.

So accustomed are we to see all these agencies set to do man's work, that we scarcely give a thought to all the weary work man had to do, all the patient often and often disappointed thought he had to expend, before he could devise and construct the very simplest mechanical contrivances, by which he could set those agencies at work to do his lightest labour. Generation after generation must have passed away before he arrived at this point of mechanical progress; and it may be almost certainly concluded, reasoning from what we know of our own capabilities of doing what is called mechanical work, and judging also from what we know of the habits and capabilities of peoples who are at present uncivilised and but little removed from the state of utter barbarism, that the purely handicraft mechanical operations would be practised for long periods in man's early history, before his experience and his growing habit of observation had made him capable of arranging materials so that with their aid he could do mechanical work. The tools of his handicraft work must of necessity have preceded then, as indeed they still precede now, the machines, simple as they would then be, constructed and put together by their help. And of the natural sources of power we have named—those of water and of wind—that of water would, in all probability, be the first to be availed of in doing mechanical work; and we may conjecture, with some degree of plausible force, that the conception of the simplest form of water-wheel would be obtained by man bathing or washing in the brook which flowed by his hut or cave, doing dreamily what we often do still, moving his hand to and fro in the water, when he would feel that it exercised a something which either opposed the progress of his hand when moved against the stream, or which tended to drive back his hand when it was left free to move. But between the conception that there was a "force" here which might be useful to him, and its realisation in the form even of the simplest water-wheel, we can reasonably conclude that many generations, almost centuries, would pass away. To make even the simplest form available, the idea of a wheel itself would have to be got hold of, and also the fixing of this upon a something which we call a shaft, axle or spindle —which itself would have to revolve or turn round. And the youthful reader may be surprised to learn that those two mechanical conceptions lie at the foundation of nearly all the varieties of mechanical combinations which, taking the form of machines doing man's work, have led up to the infinite variety of them we have now. And yet it must have been after long long years of patient thought and labour that those two conceptions—a wheel, or a circular disc, suspended or fixed to a central shaft—were made applicable to mechanical work. If the reader will but think it out, he will find that there was no greater discovery, leading to such wonderful results, as that of a carriage or war-chariot wheel and its axle, which was, in all probability, the first practical form which this great discovery took.

Considerations connected with the Discovery of the Sources of Power or Energy (*continued*).—Wind Power.—The Windmill.—The Steam of Boiling Water.—Boiling, a Science.

The main feature of the windmill is just that of the simplest water-mill—a circular wheel, and an axle or shaft; the sails, or vanes as they are called in windmill technics, catching, so to say, the air, as the floats of the water-wheel caught the water. After long years of patient and often disappointing and disheartening labour, man was able to avail himself of the three sources of force, power, or energy—namely, animals, water, and wind. But it took centuries upon centuries of experience in the observation of natural laws, before he conceived of making use of that agency which is now almost the only source of obtaining what we call motive power which is made available in modern practice—namely, steam. And ages must have intervened between the observing that the steam of boiling water had, or possessed, what we may call a lifting power, capable of producing effects similar to what we may call the shoving or moving-along power of water on a body opposed to it. Very soon after man had reached the high stage of civilisation when he became a "cooking animal," as man by some has been defined to be, and had made the great discovery of boiling liquids, he must have observed one, at least, of the characteristics of the vapour, or what we call steam. But how long it was before this was applied to the obtaining of a power which would do work, let our history show. How long it was after it had passed from the condition of a mere plaything for philosophers to amuse themselves and their friends with, to that in which it served, as at first and for long it only served, as an engine to draw water from mines and coal pits, till the genius of Watt made this engine truly a steam engine, and yoked it to every class of work, all those acquainted with mechanical history well know. The young reader, and perhaps some older ones, not initiated into the science of what are called "common things," may perhaps smile at our stating boiling to be a great discovery. But we shall have occasion, in a future chapter, or in "The Steam Engine User," to point to some considerations which will prove this pretty plainly. He will further see that boiling, as applied to the arts of industry, is really a science, involving many curious and most practical considerations; and he may perhaps be here surprised to learn that there is no theory of boiling which has yet been universally accepted as accounting for all the singular phenomena which the act of boiling exhibits. Its close connection with the steam engine is obvious, and will be further referred to in its appropriate place in a future chapter. The reason why gas, or vapour of water, which we call steam, derived from the boiling of water, as a source of power, is so universal, is that it is, so far as has yet been discovered, the most readily and most conveniently carried-out method of availing ourselves of heat. This word brings us to the consideration of one of the most important points connected with the laws of nature. How important it is will be perceived when we make this statement.

Heat the Source of all Physical Energy, Force, or what we call Mechanical Power.

Some of our readers may naturally be somewhat surprised at this statement, which is but another mode of expressing the fact that there is, so far as man and the work he has to do are concerned, no other source of what we call force, or the power to do *work*, physical work, than heat. And this after what has been said above in preceding paragraphs on the subject of the muscular force of man himself, the animals he rears and uses, and wind and water as sources of force, power, or energy. From which it would appear that those natural sources are themselves derived from the exercise, or are but manifestations, of heat. But strange as it may appear to some, this is nevertheless the absolute truth. We have not space to go into the full details as to how muscular force, wind and water force, are caused or created by heat; those details coming, in some of their aspects, under other branches of science, as chemistry and physiology. In connection with these sciences some suggestive remarks will be found in the papers entitled "The Farmer" and "The Grazier," bearing on the great question of heat as a vital power, the source of animal energy or force.

Brief General Statement of the Points connected with Heat, as the One Source of Energy, Force, or Mechanical Power.

But what we give may be stated in a very general way. The only known source of heat is the sun; from the agency of that wonderful body, which gives us light as well as heat, and of both of which as to what they really are, we know nothing—only their phenomena and manifestations or power are known, which is all that is required for the practical purposes of man—the cycle or circle of muscular force of man's or of animals' creation may thus be stated. This force can only be maintained by keeping up the supply of food; this food partaken of is through the medium of the organs of the body, and by the agency of the atmosphere, chiefly through that constituent of it known as oxygen, consumed precisely in the same way as fuel, coal or wood, is consumed in the furnace of a steam-engine boiler, and the product is heat. In our own case this warmth, or "vital heat" as it is termed, is the source of the "strength" of the body, by which its "energy" is maintained, and its "force" (see preceding paragraphs) exerted and utilised. So long as this vital heat is kept up, so long is that mysterious thing called animal "life" maintained; with the absence of *all* vital heat, death takes the place of life. And it is only during life that muscular force can be exerted; but how this is so simply by the will or the volition of man or the animals, we know not, neither of what that force really is. The food is thus directly the maintaining source of heat and of muscular force, and that food is itself derived from or produced by the action of the sun exerted through the medium of plant and soil. Some youthful reader may here remind us that man is not a vegetarian in the sense of living upon the product of plants alone—using the term plants in its widest sense as embracing all vegetation or growth in soil—but that he uses animal food as well. But the reply to this is simple: the animal man kills, and the flesh of which he eats, is itself the product of the vegetables, the grass or hay, or the turnips, which the animal eats, and by which it lives. Now, all vegetation is maintained in existence, and vegetable or plant life is created, so to say, and maintained, by heat; and the source of that heat, in all cases, is the sun. No less is the existence of that condition of the atmosphere which we call wind dependent upon the heat of the sun, and from which we obtain power through the agency of the windmill—nor less the existence of water as a source of power through the agency of the water-wheel or water-pressure engine and the turbine.

How the heat of the sun creates, so to say, these two sources of physical power or force, the reader must learn from other branches of science, with which we are not at present concerned; so also for points connected with conversion of the heat of the sun into muscular force of men and beasts.

Energy, Force, or Power and Heat, may be considered as Convertible Terms.—The Modern Discovery of Heat Equivalents in Relation to Power.—The Science of Thermodynamics.—The Application of its Laws has revolutionised the Practice of Machine Working or Motive Power.

The reader will now perceive the truth of the general statement we have made, that all physical force or power or energy—that is, the capability to do work (see "energy" in a preceding paragraph) is derived from heat; and the only source of heat we know of is the sun. Heat and force or physical power are in one sense synonymous terms, and in practical mechanics mean really the same thing, and are true convertible terms—that is, we can say, with positive accuracy, that if we have a given amount of heat, it represents or will yield a certain and corresponding amount of physical force or power; or if we have this certain amount of power, it has been obtained by the expenditure of a certain and corresponding amount of heat. If we strike a spring with a certain force of blow, represented by so many pounds, we have expended so much of our animal heat as is due to the production of that power; and so, if we have this known amount of heat at our disposal, we know that we have through its expenditure a physical force or power which will give the blow on the spring indicating so many pounds. This law of the convertibility of heat and force, or the direct relation heat has to what we call power, is but a discovery of comparatively recent date. But it may be said of it that it is that which is revolutionising the practice of modern machine working, using this term in its widest sense, as embracing all means or methods by which we can do work either as supplementary to or doing wholly away with manual labour. The law places in the hands of the engineer and the machinist a power which he formerly was not possessed of, of knowing and accurately estimating what he is doing when he is expending and using force, whether he is wasting power or utilising it with the highest degree of accuracy and economy.

THE ORNAMENTAL DRAUGHTSMAN.

His Study and the Details of its Practice, chiefly in Relation to Technical Work in Manufacturing Design.

CHAPTER VII.

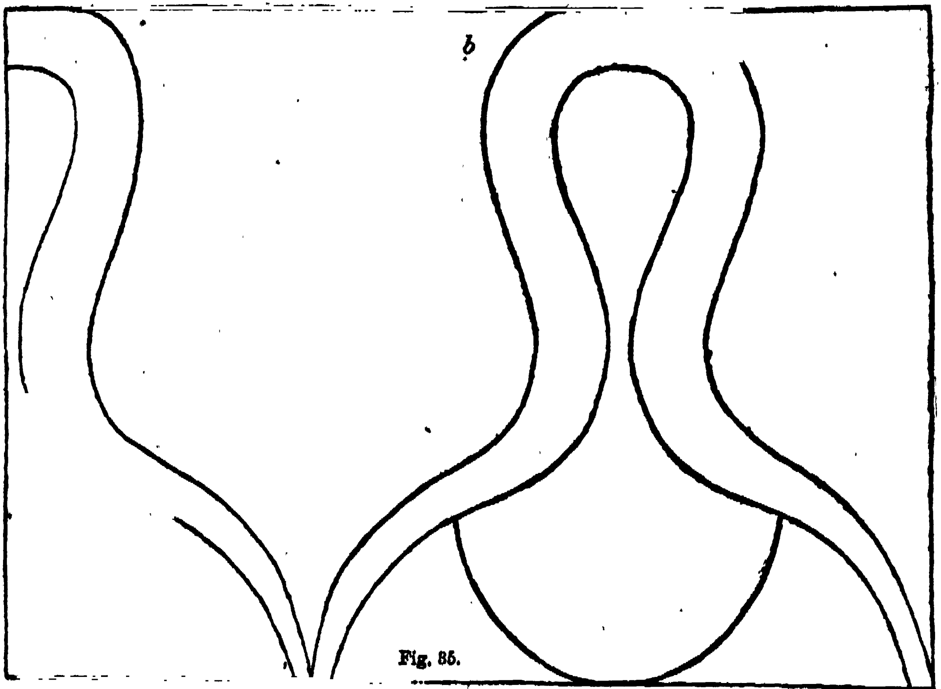


Fig. 35.

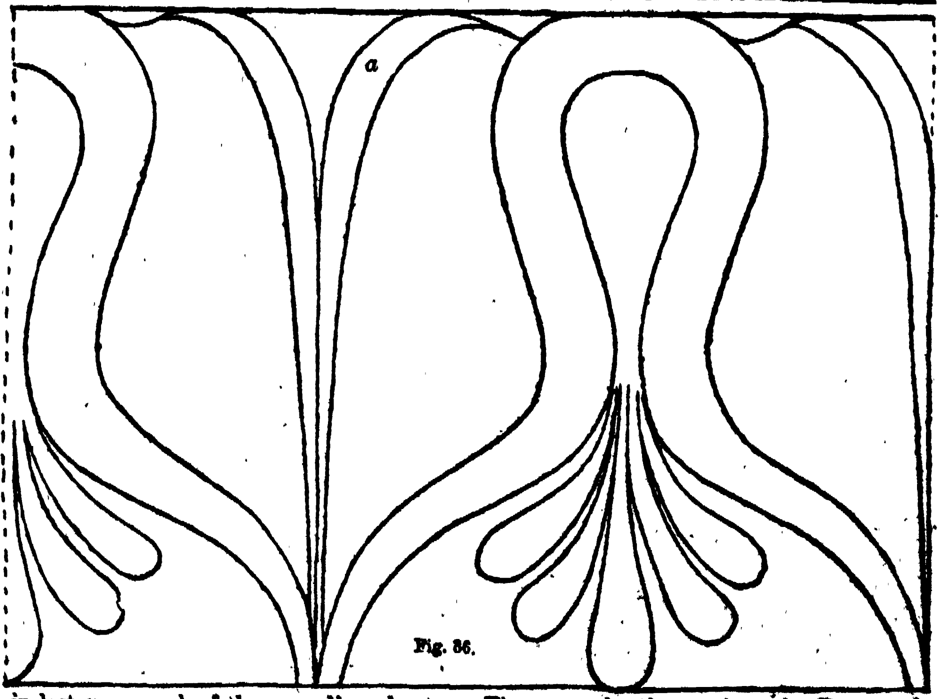


Fig. 36.

We began in last paragraph of the preceding chapter to give the student his first studies in ornament, beginning with examples of the "egg and dart" ornament. The example there given is Roman, but it was used both by the Egyptians and the Greeks; in the Greek it is different in shape. In fig. 34

the lines are of purpose badly drawn, of which the student should take note, and correct in his copy. Figs. 35 and 36 show how to draw leaf ornament used on mouldings of a different form to the last—a shape that is called the "ogee" in practice. Figs. 37 and 38 show how to draw the "acanthus" leaf moulding, and are used on the same shaped mouldings as the last example (figs. 35 and 36). As this is a most important form in ornament, we give in Plates L and LI (block), an example of the leaf.

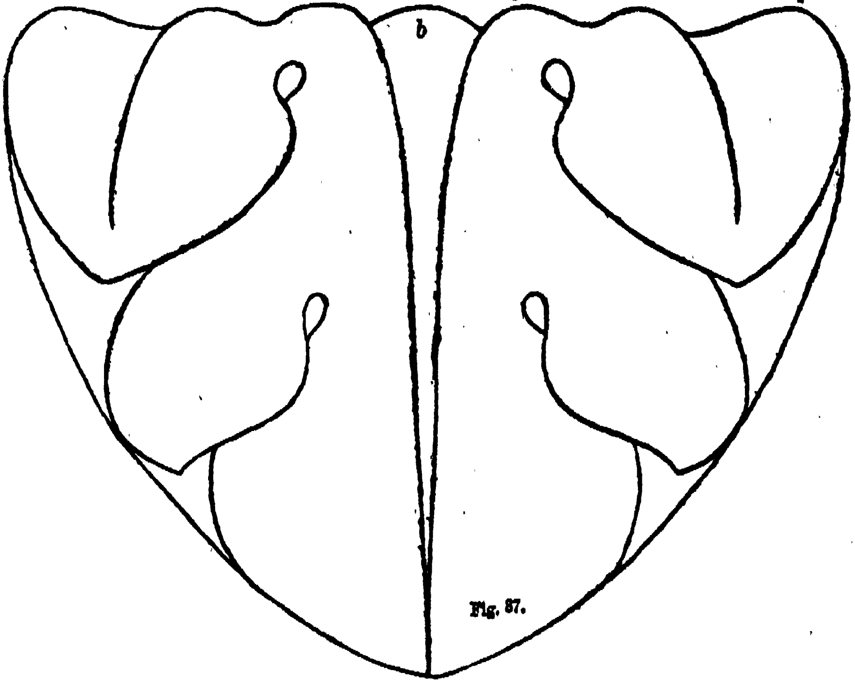


Fig. 37.

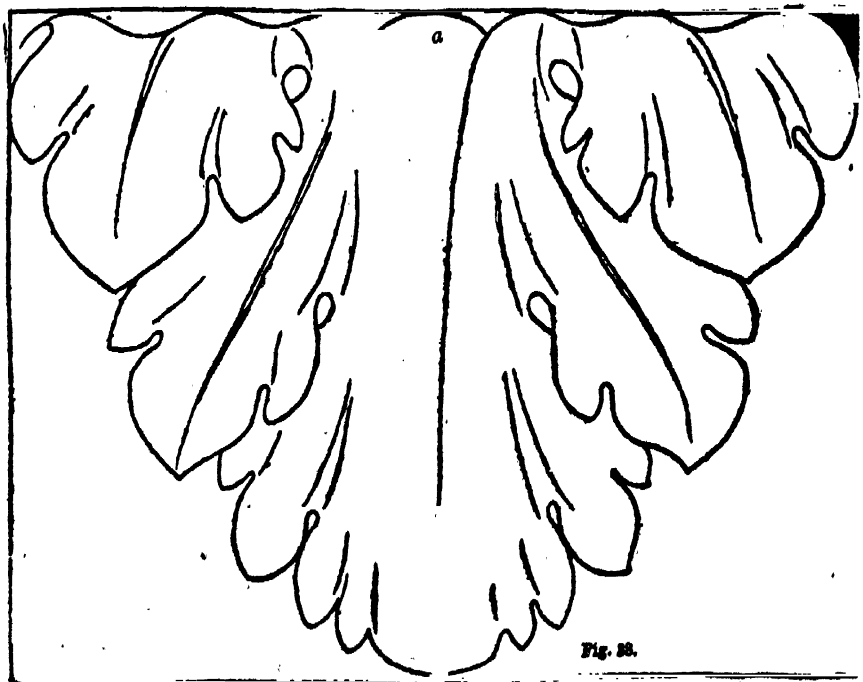


Fig. 38.

THE CARPENTER AND HIS TECHNICAL WORK.

ITS ORIGIN AND EARLY WORK—THE PRINCIPLES AND DETAILS OF ITS PRACTICE.

CHAPTER IV.

WE concluded the last chapter by referring to the use of a flat stone as a surface for a piece of timber to bear or press upon, and stated that independently of the value of its extent of surface, the relation which that bore to the position of the bearing point of the timber prop was an important element in the arrangement. For if the prop was pressing on one corner of the stone, this capability was lessened, and the nearer the end of the prop approached the centre of the stone, the better able, so to say, the stone became to resist the pressure of the prop.

In the form which we suppose to have been his first attempt to use—namely, an arrangement like the one in fig. 22 (p. 149), at *a b c d*—we are considering that the end *d* of the prop *c d* rested or pressed against a very hard and stony soil, difficult to penetrate; its capability to resist penetration of the prop being greater than the pressure put upon it tending to force it or make it penetrate the soil. Putting the two experiences together, the early carpenter would see that if he wished the prop to perform its office he would require to give it a resisting surface to press against, and that, the softer the soil, the broader that surface must be, to enable it to resist the pressure put upon it—the mere extent of surface aiding its finding the most solid "bed."

The early worker would thus receive two lessons of importance in the art of constructing timber-work: one would bear on the truth that by increasing the surface of any resisting piece or point, pressure would be distributed over a larger area, so that a material which would not bear a certain weight without giving way if that weight was applied over a very small surface, would be found to bear even a much greater weight if the pressure which that weight exerted was spread over, so to put it, a larger area. The second lesson he would learn would be that much of the value of a good bearing surface depended upon the way in which the pressing piece, as the prop *c d*, was connected at its foot *d* with the resisting member, which we have supposed to be a stone; and that it would require to be so made that it would not readily slip away from this. He would soon see that in cases of soft soil a flat piece of timber with large bearing surface would be as valuable as a resisting point as a stone would be; and that the timber would give readier facilities for forming the "joint," so to call it, at the part where the "foot" of the prop *c d* was connected with the bearing surface. Another lesson learned would show how pressure put on at one point in the assemblage or framing of timber was communicated or led to another member, and how this would, in some way or another, regulate the relation which the members bore to one another. A fourth lesson, and of the four the most valuable, if this could be said where all were valuable, would be the use of timber when under certain circumstances placed on the "slant" or "oblique." The value of this principle of "diagonal" or angular position would soon be perceived practically in relation to vertically and horizontally placed timber, in which position only the earliest timber workers used their material.

Further Developments in the Art of Designing and Constructing Framework in Timber.—The "Truss" the Essential Element in all Sound Framing.

We do not say that the early worker in timber would be aware of the fact that he had thus learned important lessons in his art. Quite possible is it that he might simply accept, as a matter of course, the facts he could not help seeing, so to say, and would, without further thought about them, and made thus aware of the value of the practice, continue to adopt it in his future work. He or some after-worker, possessed of a thoughtful mind, might really appreciate the lessons learned, and in thinking them out might deduce a theory of his own, expressing the reason why or the cause of the practical result of the arrangements adopted. Practice, we may rest assured, would long precede theory, and nearly all steps in advance. Thus, although the arrangement or assemblage of timber in fig. 22 (p. 149), at *i j m n*, would be found by the early worker to be, as in reality it is, the strongest possible combination within the reach of man; it by no means follows that he who first hit upon its conception—or rather we should say discovered its utility—could or would be able to give a reason why it was so valuable. We have endeavoured to show, indeed, that the arrangement might be accidentally discovered or be led up to by a series of natural steps, which we might say, with some truth, the early worker could not, as it were, avoid making, this being done, as it were, intuitively.

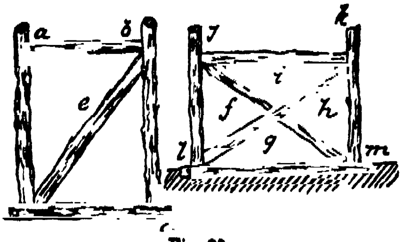


Fig. 23.

The arrangement or assemblage at *i j m n*, fig. 22, is in point of fact what in the art of carpentry is called a "truss," and in it, even in this the rudest or most elementary stage, all the elements of a well-designed modern roof (truss) are illustrated. The great principle which the "truss" exemplifies is the designing of arrangements of timber composed of horizontal and vertical timber only, and which, therefore, are rectangles, either square or such as *a b c d*, in fig. 23, so that the arrangement of the pieces or members give triangles, by the simple addition of an inclined piece or "diagonal" member, as *e*. This forms two triangles, as *a c e b*, *d c e b*; or four, as the triangles *f*, *i*, *g*, and *h*, by the addition of two diagonals, *f* and *h*, between the two vertical posts, *j l*, *k m*, and the two horizontals *j k*, *l m*. But although assemblages or arrangements of timber in which diagonals were introduced, cutting up, so to say, the old or original rectangular forms into triangles,—thus giving the strongest of all forms,—would be long followed, it is by no means to be concluded that the "reason why" this triangular arrangement was so strong would be understood. We conceive it to be a very probable thing that it was only at an advanced stage of educational civilisation, so to term it, that some thinkers, taking the forms of timber arrangement which practical workers had long adopted, deduced the theory of the truss. And we may rest pretty well assured that it was only by a series of tentative trials or of lucky hits that the full value in practice of the principles we have endeavoured to explain became known to timber workers.

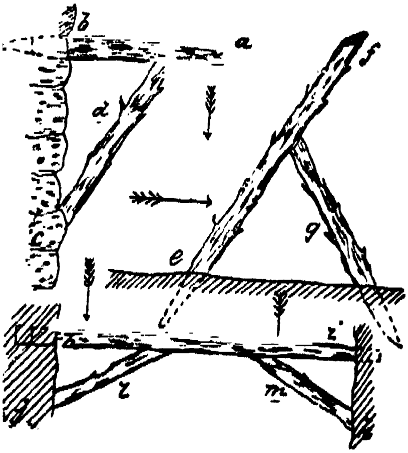


Fig. 24.

Further Illustrations of the Principle of Diagonal Adjustment of Members or Pieces of a Timber Framing.—Strutting or Bracing of Timbers.—The King-Post Truss.

We have thus illustrated one or two of the earliest applications of the diagonal member in framing —we show one or two more in fig. 24. The piece *a b*, projecting from the face of a rock or bank of earth, or a wall *b c*, is made capable of resisting greater weight or pressure put upon it by adding the prop *d*, as in like manner the piece *f g* is made capable of resisting pressure by the addition of the prop *g*, and the piece *h i*, which we may suppose to be a trunk of a tree thrown across as a bridge, an opening, or "void," between the two cliffs, as *h j*, *i k*, is strengthened by the two props *l m*.

We have said that the assemblage of timber in fig. 22, at *i j m n*, illustrates all the parts of a modern roof truss of the class known as a "king post" and "roof," and that this gives the strongest combination of timber. The "pressures" are so "distributed," and are "communicated" or led in such directions, that they are all concentrated, so to say, at the points of greatest resistance. Thus in the case of a simple or rude form of a roof truss, *a b c* (fig. 25), the pressures are thrown upon the walls, *f*, *f*, and consequently an assemblage of timber can be designed which can be thrown across a "void" or opening, as *f f*, as in the case of an assemblage as at *g h i j*, which may represent a partition stretching across the void *k* of an apartment or space. Trusses may be, and are, as we shall see in succeeding illustrations, of various forms; but in all of them, by the use of diagonally placed timbers, triangles are formed.

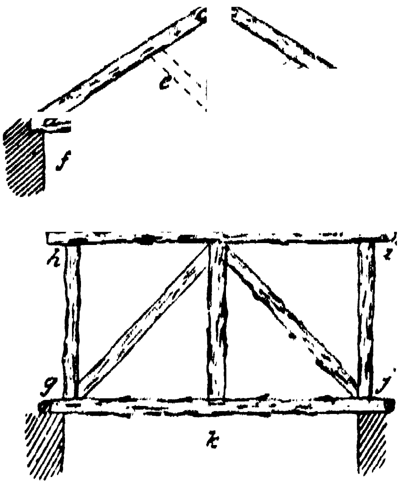


Fig. 25.

Technical Terms applied to the Individual Members or Pieces of Timber Framings.

We have called hitherto the piece or member, *c d*, in fig. 22, a prop. This is a popular term for it; but it became, and is still distinguished in technical carpentry phrase, as a "strut" or "brace." The technical name for the member *a b* is still, what we have as yet called it, a "post." Used in a certain way, a post so placed becomes a column, pillar, or standard. The member, as *h i*, in fig. 24, is called a beam, if of comparatively large section; of the largest, it is termed a "girder."

THE FACTORY OR MILL HAND AS A TECHNICAL WORKER.

THE ORGANIZATION, GENERAL DUTIES, AND SPECIAL WORK OF THE STAFF OF FACTORIES FOR THE PRODUCTION OF SPUN AND WOVEN GOODS—THAT IS, "YARN" AND "CLOTH"—AND THOSE CHIEFLY IN COTTON AND WOOL—GENERAL DESCRIPTION OF THE VARIOUS PROCESSES OF MANUFACTURE.

CHAPTER IV.

The Vertical Cotton Opener (*continued*).

FROM the statement given at end of the preceding chapter the reader will at once see how the tender fibre of the cotton is subjected to breakages of the staple. This damage to the cotton fibres ought to be avoided in every preparation through which the cotton has to pass. This vertically-working machine has a beater, but no feed-rollers, nor any other similar arrangement whereby the cotton is so *held* to be beaten, and probably broken. It receives its cotton, not by rollers, but by the suction or the draught of the beater itself. This beater or shaker is of a conical form—that is, the arms of varying length form in their outline an inverted cone. The small end—that is, the shortest series of arms—is near the bottom end of the shaft, and nearer to the tube through which the cotton is fed by hand. The cotton thus drawn into the smaller end of the cone, the lumps or tufts of fibre are broken up more gently by its smaller diameter. The reader should bear in mind that the cotton is drawn into the cone by the draught which is caused by its revolution, it making something like a thousand revolutions per minute. And in addition to the draught formed by the cone, a fan is so arranged as to draw away and pass to the open air the dust which is created by the opening of the cotton; it also creates a draught, which helps to draw the cotton from the tube from which it is fed. The cotton thus comes in contact with the beater, as we have before noticed, free from any arrangement whereby the cotton is held until it is beaten, or, in other words, "torn asunder." The beater is surrounded by what is termed a grate or grating, through which the dust or seeds or shell, or any other useless matter, is drawn away into a room called a "dust chamber." This conical beater performs its work automatically; *i.e.*, all the heavy, lumpy cotton remains at the lower part of the cone until it is opened and freed from that part of superfluous matter which all cotton contains, and as it (the cotton) is more opened it becomes lighter, and thereby rises up to the larger part of the cone, and this being larger in diameter, the cotton, in its loose and light condition, has more room to be dashed about and to be further opened and cleaned. When the cotton is so cleaned and lightened, it is then ready to pass away. The outlet being at the top or broad part of the cone, the cotton passes out on to an endless apron, and is thus conveyed to where it is required for the next machine (scutcher or lap machine).

Some Practical Considerations connected with the Process of Cotton Opening.

The reader may have observed that this machine acts upon the cotton as though there was a power of thought about it—*i.e.*, by keeping or retaining the matted or lumpy, heavy cotton at the lower part of the cone, until it is partly opened. The cotton while in this lumpy condition requires to be treated less furiously, and so it is less harassed until it gets partly opened; the lighter it becomes the more readily does it rise. The machine does not think, but the arrangement of it is such that the natural consequence of the material being close and heavy, its inclination is, like all other heavy bodies, to fall, and the smaller part of the cone treats the cotton more gently, and thus prepares it for further treatment, which according to its condition it requires, and which, of course, it receives. It must be evident to all readers, whether practical cotton spinners or mere theorists, that to destroy the fibre of the cotton, in whatever process it may be passing through, is detrimental to it in the finished condition, and thereby it is of the utmost importance to guard against this taking place. This breaking or shortening of the staple tends to making more waste, and thus not only interferes with quality of goods, but, in the second place, it increases the cost of the finished article. This waste is rarely ever detected until the yearly account is made up—nay, very seldom then is it discovered except by comparison with some well-known and economically managed mill. Some declare that a certain percentage of "waste" is all that should be made in working American or Egyptian or Indian cotton. We maintain, and from experience, that it is a very difficult thing to fully ascertain when and where unnecessary waste is made. Let us suppose that a machine in the blowing-room or opening-room is in any way damaging the fibres of cotton: this misfortune (we deem it to be such) is not easily detected, simply because, if the staple is broken in the first or second machine, the broken staple is not left as waste in

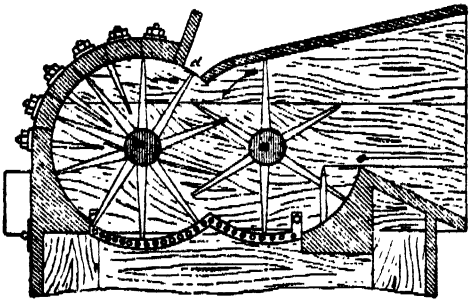


Fig. 1.

that room, but is continually losing the "shorts" through every process which it has to undergo, and hence the difficulty in ascertaining the precise machine where it is created. This being the case, the manager requires to be on the alert, and not be simply satisfied with the machine because it is from a machinist of high standing. We think it a duty of the principal or manager of the works to carefully think over the way by which the cotton is manipulated, and to see, as far as circumstances will permit, that the cotton is not harshly treated, *i.e.* more severely than the staple is prepared to bear without breaking; and therefore, to avoid this, the general examination of the principle will, with a thoughtful man, lead him to a decision as to the best thing to be done, and what he should avoid.

Before passing on to the next process in cotton preparation, we give here a diagram which will illustrate the general principle both of the "willow" and of the "porcupine" opener. This special form of cotton opener is much used in America, and called a "whipper." This is shown in action and construction by fig. 1. It consists of two iron axles, *a*, *a'*, which are enclosed in wooden boxes. These axles are placed in a horizontal position on a frame, and parallel to one another, and have projecting from their circumferences six rows of iron spikes. From the inside of the boxes similar spikes spring, and are placed in such a position that between each two spikes of one axle a spike from the box or from another axle passes. The cotton is put in at the opening *d*, is quickly turned round and separated by the spike immediately underneath, and is thrown out by the spikes of the second axle, at *e*. The axle *a* makes about 1300, and the axle *a'* about 1500, revolutions per minute, and 124 to 150 kilogr. of cotton can pass through the machine in an hour. To drive the machine, about ¾-horse power is required. From the "whipper" the cotton is taken to the scutching machine, beater, or blower. The object of this machine, fig. 2, is to still further clean and open the cotton by means of iron frame-shaped beaters which are also enclosed in boxes.

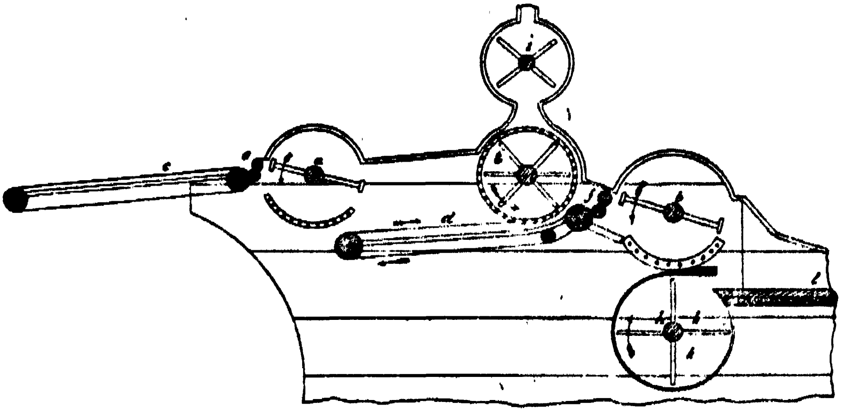


Fig. 2.

The Cotton "Scutcher," Beater," and "Lap" Machine.

Cotton well opened and well cleaned—that is, freed from impurities, viz., seeds, shells, dead matter, dust, and some of the "shorts" of the fibres, which are little better than dust—is ready for the next process. Being well prepared by the opener, the following machine has not the same chance to damage the staple. Nevertheless in our experience we have found that cotton is often damaged in the machinery of what is called in a mill the "blowing room." The blowing room in many of the mills contains both the "opening" machines we have described and the "scutcher," or "lap" machine, now to be described and illustrated. The principle upon which the "scutcher" (fig. 2) operates, and its general construction, will be shown in this diagram, in which two beaters, *a* and *b*, enclosed in casings, act upon the cotton, which is conveyed by the endless apron *c*, and by the feeding rollers at *e*. The first beater, *a*, throws the cotton on to the endless apron *d*, upon which it is slightly compressed by the wire or open drum *g*, and then taken by the second pair of feeding rollers, *f*, to the second beater, *b*. The cotton then either falls on to a perforated wooden tray, or else on to another endless apron connected with a wire drum or cage, from either of which it is wrapped up in the form of a "lap" or continuous roll of what is popularly known as wadding. The ventilator *i*, with four vanes or arms, (which is situated above the drum *g*,) removes dust and sand; and a fan *h* connected with the second beater, *b*, by drawing in a current of air at the opening *k k*, keeps the cotton in the stage or apron *l*, in motion. The first beater, *a*, makes 1000 to 1600 revolutions per minute consequently its two arms give 2000 to 3200 blows

THE JOINER.

The General Principles and the Details of his Work.

CHAPTER V

The "Mitre" Joint (*Continued*).

The end of the piece *a b*, fig. 37 in last paragraph in preceding chapter, to be joined, is cut with a mitre—that is, the face, as *e f*, is at an angle of 45° with the line of the length of the piece. A modification of this, but more complete, is shown in fig. 38, in which a double shoulder is given—a shoulder being cut, as at *c*, in piece *a a*, shown separately, a corresponding part being cut out in piece *b b*, as at *d*; *b' c'* is end view of *b b*. Another modification is shown in fig. 39, which is a combination of the square and the mitre joint, the part from *b* to *c* only being "mitred," a square-faced shoulder or return joint being formed at *c d e*. The lower drawing in the diagram gives the appearance of the end of part *b b* when viewed singly, *b' c' d' e'* the end of part *a a*. *a'* and *d''* is edge view of end of part *a a*, or *b' c' d' e'*.

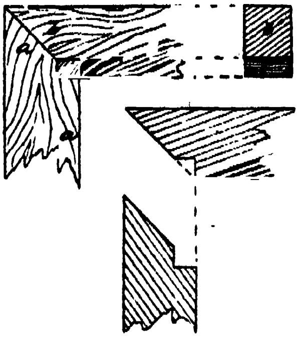


Fig. 38.

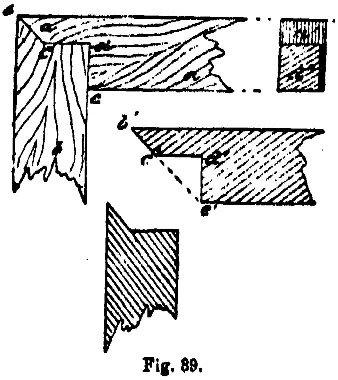


Fig. 39.

Further Illustration of Joints on the Mitre Principle.—Pieces at Right Angles.

In figs. 40, 41, and 42 we illustrate joints at corners of pieces joining at right angles on the "mitre" principle, and which are by the form of joint employed secured from being separated by lateral strains. In fig. 40 the faces of each "mitre," as of piece *a' a'* and piece *b b*, has a part or "slot" or "chase" cut out, as shown at *c' c'*. When the pieces are placed together, as at *a a*, *b b*, these form an opening, as *c*; into which a "key" piece, or "dowel," exactly equal in length to the thickness of *a a*, *b b*, is driven in tight up, thus holding the two together. An inside view looking edgeways of the piece *b b* is shown at *d e f g*, being the face of the "mitre," *c'* being the part cut out. In fig. 41 the vertical piece *a* is joined to the horizontal piece by a joint, of which *b f c* projects, and the part cut out at *c' e' d'*, as shown in the

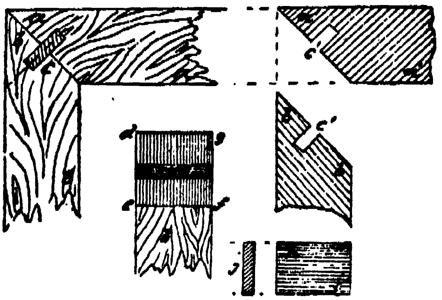


Fig. 40.

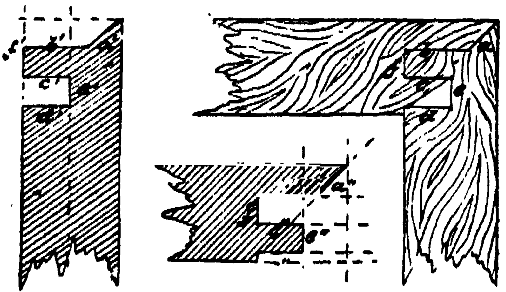


Fig. 41.

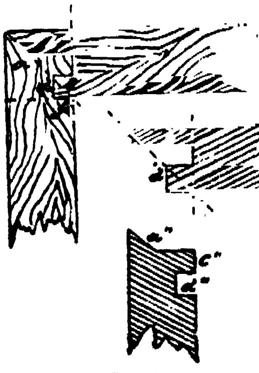


Fig. 42.

diagram to the left; the horizontal piece having corresponding indentations, as *b″ c″*, and projection *e″ d″*. Fig. 42 is a more simple form of the same kind of joint, corresponding letters accented showing corresponding parts.

Other Forms of Joints for Pieces cut at Right Angles to each other.—Oblique Joints.

In figs. 43 and 44 we show forms of joints where the pieces are not at right angles to each other, but form an angular part or corner, as at *e*. The ends *b b* (fig. 43) of the two pieces *a a* and *c c* are cut or squared off at the desired angle, transverse grooves being cut in the faces and centres of the joints, into which a dowel or feather *d d* is driven, being squared off at the ends in order to be flush with both faces or surfaces of the pieces *a a* and *c*; the diagram to the right shows elevation of face of one of the pieces, as *a a*. Fig. 44 is another joint of the kind on the same principle as in figs. 43, 41 and 42.

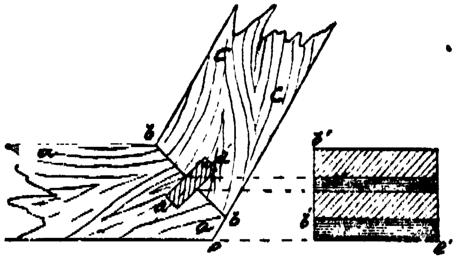


Fig. 43.

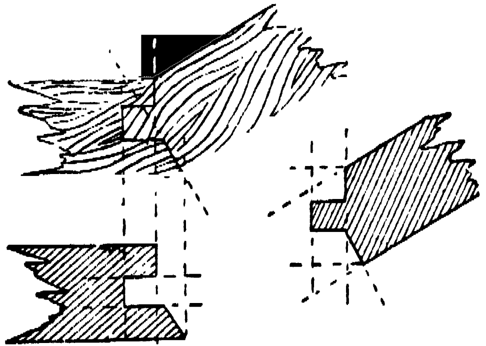


Fig. 44.

Forms of Mitre Joints Tongued and Grooved.

In figs. 45 and 46 we illustrate a form of "mitre" joint with mortise and tenon, or tongue and groove, frequently used in joining pieces at right angles to each other. The ends of the two pieces are first "mitred" or cut off at an angle of 45° to their length, as at *a b*, *e i*. But the one piece, as *e f*, is not cut flush or across the full face, but a part, as *g h i*, is left in the centre of the thickness of face, forming a tenon or tongue. A mortise or groove, as *g h*, fig. 45, is cut in the mitred face *a b* of other piece, to receive the tenon *g h i*, and in position, as at *b c d*, corresponding. *a′ d g h* is end view of part *j h i f*. In fig. 46 the face *a b* of the end piece *a a* is "mitred"; and the face *c d* of the piece *c* mitred also, but the tenon or tongue *f* in this case extends the full length of the face of *e*, not cut short, as at *g h* in fig. 45; *a′ b′* is the elevation of the face *a b*, with mortise *g* cutting in *c′ d′* is plan of lower edge of piece *e*, *g′* being the tenon or tongue. The positions might be reversed, the tenon being cut on piece *a a*, as at *h j i*. The lower diagram to the left shows the face of *a a* as provided with three mortises; tenons are cut on the end of the other piece.

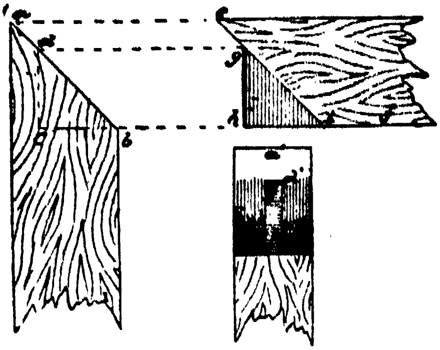


Fig. 45.

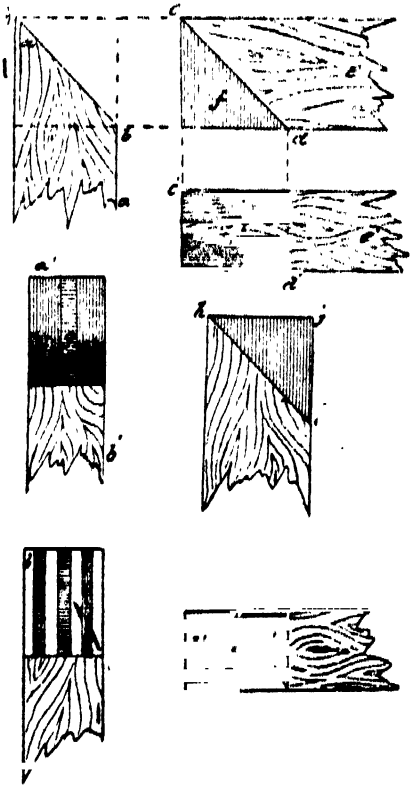


Fig. 46.

THE WORKMAN AS A TECHNICAL STUDENT.

HOW TO STUDY, AND WHAT TO STUDY.

CHAPTER IV.

The Real Difficulty in the Way of carrying out an Extended System of Technical Education.

MEANWHILE we may state here generally that these causes will be found to be almost wholly personal. The difficulty which nationally we have to face in solving the technical education problem is not, we venture to say, the establishment of the machinery of education. We nationally are wealthy and willing enough to give the means for this, and more would have been given before now—much as is now given—had there not been at least a latent if not expressed notion in the minds of many that all the machinery in the world will not do its work unless the machines are fitted for the material and the material for the machines. That in our systems of technical education—such as they have been—we have not paid due attention to the "material," not a few thinking men amongst us have unmistakably concluded. The students, who constitute of course the material here named, have, like all other materials upon which machinery has to operate to bring about a certain result—to do, in fact, its "work"—have the peculiarities of social position, which are somewhat difficult to deal with, inasmuch as they involve the question of time for and of physical ability to study; the students we wish to become educated technically have also their peculiarities of individuality or personality, which are still more difficult to deal with. But all of these *must* be dealt with if we really purpose nationally to solve the problem of technical education. And we venture to say and hope in the course of the present chapter—as also in some parts of the series entitled "The Technical Student as a Workman—his Daily Work—his Privileges—his Duties, Responsibilities, and Rewards"—to be able to prove that hitherto we have not yet nationally even taken into consideration those peculiarities; far less formed any adequate notion of how potent their power is for evil or for good, just in proportion as they are neglected or abused, or, on the other hand, taken note and availed of. If nationally we had done this there is in the minds of many practical thinkers no doubt but that we should have made greater progress in solving the difficult problem of national technical education than we have as yet made. Had we paid attention to those peculiarities we take leave to think that it would not have proved so difficult of solution.

Further Considerations connected with the Important Point named in Last Paragraph.

Expressions or illustrations which are said to be familiar are by some considered as undignified, if not degrading, when introduced into what they are pleased to term dignified subjects. Holding, as he does, that no honest work can be otherwise than dignified, and that familiar expressions are dignified or otherwise according as the motive is for using them, or that to which they are applied, the writer does not think it beneath the dignity of his duty, at once to this important subject and to his readers, to use what are called familiar illustrations, when they can help forward the interests of those readers who take up the study of the subject. In connection, then, with what we have said in last paragraph on the subject of the machinery of technical education, we here use, as conveying in reality a vast deal of practically suggestive truth, the familiar expression or saying that "we may take a horse to the water, but we cannot make him drink"—nay, to put it conversely, if by circumstances, no matter what, we cannot take the horse to the water, we may even go to the trouble of taking the water to the horse. And yet we may find the same difficulty to deal with, and we may not be able to make him drink. Further, if after we have somehow given him the supply we muzzle the horse, should we be wise or foolish if we then expected him to drink? Or some physical circumstance might, so to say, muzzle the horse, so that even if he would he could not drink, being in any case muzzled. If we did not muzzle him ourselves, but nature or accident had done it for us, we, if we were wise, and the horse at all valuable, should call in the aid of the veterinary surgeon in order to enable him to use his natural or physical peculiarities, or unmuzzle him. To use another familiar saying, "The force or truth of the proverb or story lies in its application." We leave our readers to make the application of the familiar expression we have above used, and if they take them in connection with preceding paragraphs they should make it easily and readily. Its various practical applications will come up in due time and course, as we give what it is to be said in the how to study and the what to study of the workman as a technical student. And we reasonably hope to be able to prove the truth of the position we have assumed, and that deduced from the definition we have arrived at of the term technical education. This position may here again be briefly formulated: that of the influences which naturally exist and which can be brought to bear upon the work of technical education, *all* must be availed of before that work can be said in the true sense of the term to be done. And we shall find, as we proceed, that some of those have not as yet, at all events, been taken generally into account as factors—certainly not as important ones—in the solution of the important problem, now more than ever engaging the attention of the nation, how best to give to our technical workmen the advantages of technical education. To this important task, and all the weighty considerations it involves, we now address ourselves.

Working Men Handicraftsmen in Relation to Technical Education.

Taking all the classes engaged throughout the country in the varied branches of industrial work, and viewing them as a class, there is one term which may appropriately enough be applied to its members, and this is that they are all handicraftsmen. We shall see presently that there is nothing derogatory to the true dignity of workmen in thus applying to them this term. All honest work is dignified in and by itself, when done honestly—that is, conscientiously—and work is all the more dignified the more that mind is thrown into it. This we now come to consider.

Handicraftsmen the Old Name for Artificers or Working Men—What the Term Involves.

In using the term handicraftsmen we mean that the chief characteristic of their work is that it is done by the agency of the hands. Now, this distinction, which is certainly clearly marked, has a very decided tendency to create the idea that their work derives its value solely from their manual skill and dexterity. This would be quite true if the term handicraft were absolutely correct. But it is not so. It may indeed be taken to be a truth, that there is scarcely one of the many kinds of hand-work but what presupposes, indeed, demands, the previous exercise of mental thought. When the necessity for doing a certain kind of work arose, the first man who attempted it must have given some thought as to how it could be done. How best to do it would be a work of time in the great majority of cases, for as practice enlarged, methods of overcoming its difficulties would suggest themselves, and by first trying one way and then another, the best way of doing the work would be discovered. But it would only be by practice more or less long continued that this, the best way of doing the work, could be done deftly, in the quickest and most certain way. And although, when once discovered, this method could be handed down from one generation to another, it by no means follows that each succeeding handicraftsman would equal his predecessor in the skilful way in which he carried the method out. That would depend not merely upon his manual dexterity, his handicraft skill in short, but upon his mental capability to grasp clearly what the work was which he was called upon to do. Nor would his value as a handicraftsman be independent of certain moral qualities which he might or might not possess—such as honesty of purpose to do his work conscientiously, and habits of perseverance, so that he would not do his work by fits and starts. And as human nature varies exceedingly in its manifestations, so also would these attributes vary in different men, so that while one would be esteemed as a good and faithful workman, so would another be of that unfortunate class who are known as worthless fellows. And so also would varied skill in handling the implements of work, and varied capacity to estimate the character of the work itself, be met with; and thus, even in the earlier days of the world, the classes of the skilled, the indifferent, and the bad handicraftsmen would be found to exist.

Mind a Characteristic of all Good Handicraft Work.

We thus see that in the closest way mind is associated with what is but too frequently asserted, and indeed by the vast majority supposed actually to be, mere hand-work or manual labour. And although the work of some handicraftsmen may be said to be so purely mechanical, done so intuitively and readily, that no mind is required in the doing of it, it may fairly be questioned whether there is any class of work which cannot be better done in every sense of the term by giving thoughtful care to its execution, in other words giving mental power to it. We have said that by experience the best way of doing any piece of handicraft work would in time be discovered, and that this one way of economically overcoming the difficulties attendant upon the doing of it could be handed down from father to son. But apart from the fact that this inheritance—so to call it—would in value be influenced, as we have seen, by the difference there is in the capabilities of one man as compared with those of another, this further consideration has to be taken into account. In stating that the best way, once discovered, could be perpetuated by descent, we have presupposed that there would be only one direction in which the "best" lay. But while it is true that in some classes of work its peculiarities are such that it admits of a uniformity of performance—the method used once can be used always—it is none the less true, as not a few of our readers well know, that the peculiarities of work in general vary much—vary almost, indeed, with each particular piece of work to be done. This arises from changes or varieties in the character or nature of the material which is being operated upon. This may at one time be such as to present greater difficulties than part of the same substance may present at another; hence difficulties which do not exist one day may arise on another. Here it is obvious that thought will be demanded of the handicraftsman in order to overcome those difficulties as they arise; and in the capability to give that thought, and in the way in which it is exercised, lies the reason why one man is said to be skilled, another the reverse, as a handicraftsman. Hence the erroneous idea, which is all but universally accepted by a wide class of workmen, that no head-work is required in the doing of handicraft work.

THE BOAT AND SHIP BUILDER.

OUTLINES OF THE PRINCIPLES AND PRACTICE OF HIS ART.

CHAPTER IV.

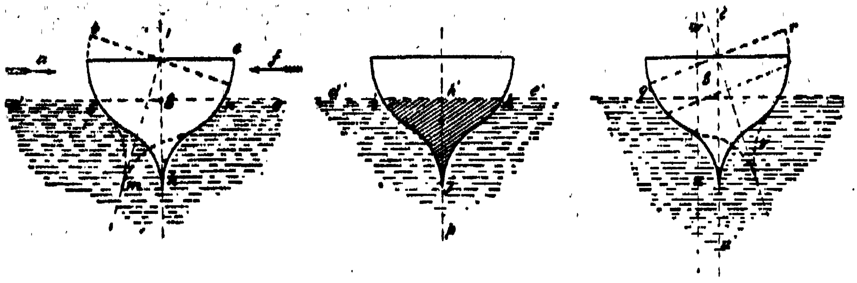


Fig. 5.

IF the reader will turn to the last paragraph of preceding chapter, he will see what we have said in treating of the centre of buoyancy as to the pressure upwards of the water in a floating body. But this pressure of the volume of water, as *k l m n*, or as *b f g c*, in diagram fig. 3 (p. 318), is also opposite to the pressure or force exercised by the tendency of the floating body to sink. That is, both pressures acting in opposite directions lie in the same line, and being equal, balance each other, or are *in equilibrio*; and the body, as at *a* or *c* in diagram fig. 4, is at rest or in equilibrium, and therefore floats. But although bodies such as those shown may thus, under normal conditions or circumstances, remain in the upright position, and may thus in a certain sense be said to be stable; their true stability rests in this—that their floating power, so to call it, should be such that when subjected to any force or pressure which, acting, say in the direction of the arrow *a*, diagram fig. 5, tends to make the vessel "heel over," or lean to the right, as shown in dotted lines, will, when that pressure or force is either taken off or lessened, enable the vessel to return to the normal position, or that in which its deck, *b c*, is parallel to the plane of flotation or level of surface of water, *d e*. This capability of a vessel to return to its normal position, or, as it is technically termed, to "right itself," gives it its true stability. On the contrary, a vessel is said to be unstable, or is incapable of "righting itself," if when a force as represented by the arrow *f*—or equally as at *a*—acts on one side, tending to push it, say towards the right, and gives it a tendency to deviate further and still further from the normal position, till it is completely upset. It is scarcely necessary to say to the young student that a ship to be safe, that is, useful for carrying purposes, must be "stable," that is, have a capability of "righting itself" when placed under the influence of the forces of winds and waves tending to shove it aside, and must not "heel over" too much, and thus be upset or "founder" at sea. The mere stability of a floating body, as at *a* or *c*, fig. 4, in the normal position, when it, so to say, sits vertically in the water or "swims fair," is always secured, because the line drawn from its centre of gravity vertically, as *a g* or *c i*, falls within the base or the plane of support. And this, which we may call the vertical or normal stability, is in no way disturbed by any force acting vertically, as in the line from *a* to *g*, as when the vessel by having more cargo or weight put "on board" sinks deeper in the water; or when conversely the force acts upwards in the vertical line, as from *g* to *a*, when the vessel, being lightened by having its cargo or weight taken out, rises in the water. For in the case of sinking or "deeper dipping," through increased weight or cargo, the volume of water displaced is increased also, so that as the bulk of the vessel is a constant or unvarying quantity, there is an increase of holding or forcing-up pressure exercised on the vessel by the water which gives a tendency to the vessel to rise, and thus the vertical or normal stability is maintained. And again, in the case of the vessel rising when lightened of cargo or weight, there is a displacement of a less volume and weight of water; so that there is an excess of downward pressure tending to bring the vessel down, and thus still maintain the vertical or normal stability. But the condition of floating which gives to the vessel the capability of resisting forces which make her "heel over," and keep her heeling over till she may be absolutely upset, is what we call the "true stability." And this is secured by having a due relation of the floating vessel to the volume of water which she displaces. The two pressures or forces of those we have shown to be equal and opposite, and to be therefore on the same line—and this line is vertical, having for one of its points the centre of gravity of the floating body, as *g* in fig. 5, and the other the centre of gravity, as *h*, of the volume or body of water displaced by the vessel, and which is obviously the form *i j k*, equal to *l h n*. This is the condition of what we have called the normal or vertical stability, and which two forces are equal, but acting in exactly opposite directions, and therefore balancing or neutralising each other, act along the same line. This line, as *o p* in fig. 5, is technically called the "*line* of flotation," the *plane* of flotation being, as already shown, the line or level of water, as *d e*, *d′ e′*.

Relation of Centre of Buoyancy to Centre of Gravity affecting the Stability of Floating Vessels.—"Even Keel."—"Heeling-over."

But the young reader will perceive that a vessel or ship, under ordinary circumstances of voyaging, is placed under such conditions that, excepting in cases of a dead calm, or when so acted upon by wind that she sails on what is called an "even keel"—in which case she is in the position which we have called her normal or vertical stability—she is liable to be acted upon laterally, so that she "heels over," or has her deck line oblique to the plane of flotation, as for example at *q r* in diagram fig. 5. The "centre of gravity" is therefore continually, or liable to be continually, changing under the pressure or force of winds and waves; it may be to the left, as at *s*, when the pressure comes from the right, or conversely, by a normal line, as the line *o p*, which passes through the two centres when the vessel is in its position of normal stability. But the position of the centre of buoyancy is also changing when the vessel is placed under the changing circumstances of actual work, when subjected to the pressure of winds and the force of waves. For, as the vessel heels over either to the right or left, as at *a b* or *c d* in diagram fig. 6, it is obvious that the form or the section of displaced water, as at *e f g*, or *h i j*, in relation to the plane of flotation or level surface of water *k k*, is very different from the form or shape or section of the displaced water, as at *i j k*, diagram fig. 5, in relation to the line *k k*, fig. 6, or the line *d e*, fig. 5. We shall see, in connection with illustrations yet to follow, how this change of position of the two centres affects the stability of a ship. Taking the position as at *q r*, fig. 5, and dropping a line *w x* through the centre of gravity, in which line gravitation acts on the vessel, we have now two lines of forces. But although, as always, those forces act in opposite directions, and are still equal, they do not act directly or along the same line, but form two lines, *t u*, *w x* (fig. 5), parallel one to the other. These lines form what in scientific technical phraseology is called a "couple." And the resultant of this couple, or of the two forces acting thus in parallel lines, is a force which tends to change the floating vessel, giving it an angular position—that is, with its deck line at *q r* forming an oblique line with that of the plane of flotation, as *d e* or *d′ e′*. If the ship or vessel is so designed that, when loaded with her estimated cargo, she has "true stability" (see preceding paragraph)—that is, can right herself when a force or forces cause her to "heel over"—the "couple" is termed a "righting couple." If the converse is the case, then the "couple" of forces acting in parallel lines, as at *t u*, *w x* (fig. 5), is called an "upsetting" or "overturning couple."

Other Terms in the Art explained.—Centre of Displacement.—A Vessel righting itself.—Loading of a Vessel.—Deck Cargoes.

We have seen that the "centre of buoyancy" of a floating vessel is the centre of gravity, as *h* or *g*, diagram fig. 5, of the mass or volume of water—as *l m n*, *i j k*—displaced by the vessel; hence the term "centre of displacement" is by some given to it. Now, a "righting couple," or that which gives true stability to a floating ship or vessel, is that in which its centre of gravity, as *l*, diagram fig. 6, is always *below* the centre of gravity, *m*, of the mass of displaced water. If in this relative position, when the two forces constituting the couple cause a "heeling over" of the ship to the left, as at *c d*, or to the right, as at *a b*, it will "right itself" on the forces lessening or being removed. If the relative position of the two centres of gravity be changed so that the centre of gravity *n* be *above* the centre of gravity *o* of the displaced water, then the couple formed, as at *p q*, will act as an "overturning" force, and the vessel will not be self-righting. The young student will see from this the practical necessity of so "loading" a vessel, or "stowing" away its cargo, that the heavy articles will be placed in the lower part of the "hold," thus throwing its "centre of gravity" low, so that it will be below the "centre of buoyancy" or "displacement." He will also see the danger, of which so much has been heard of late years, of having what is called "deck cargoes"—that is, goods stowed away upon the deck, which have a tendency to raise the centre of gravity of the ship, and may place it too near, if not actually at, or—what is fatal, as we have seen, to true stability—above the centre of buoyancy or displacement. When the two centres are coincident, or the centre of gravity meets in the same point as the centre of buoyancy, the vessel is indifferent as to position, and will therefore be in equilibrium in any position. Another practical point of importance, as bearing upon the true stability of a ship, or its capability to right itself in all conditions in which it may be placed, is the stowage of the cargo in such a way that none of it will get loose and roll to one side. In this unfortunate condition, but too often experienced—and which has doubtless been the cause of ships' foundering at sea of which nothing has ever been heard—if those loose goods, when heavy, roll over to the side to which the ship is being heeled over, they may so weigh the ship down towards that side, changing the position of the centre of gravity, that the vessel cannot right itself at all, or so slowly that heavy seas may be shipped, and it may become unmanageable for a time, and great damage done, and risk of total loss may be run.

Some other Points connected with the Stability of Ships.—Rolling.

We thus see that what may be called the normal "centre of buoyancy or of displacement" is that in which, while the vessel is at rest, as in a dead calm or in dock, this centre and the centre of gravity of the body or mass of displaced water are in the same vertical line, but in which the centre of gravity of the vessel is below the centre of buoyancy; what may be called a new series of centres of buoyancy is being erected by the continual change of the position of the vessel when sailing under the influence of the wind and waves, or when "rolling" while lying-to or at anchor with a heavy swell on. The points connected with those changes, and which have partly been already explained, will be more completely examined at a future part of our paper, when other points connected directly with or bearing upon them, will fall to be considered.

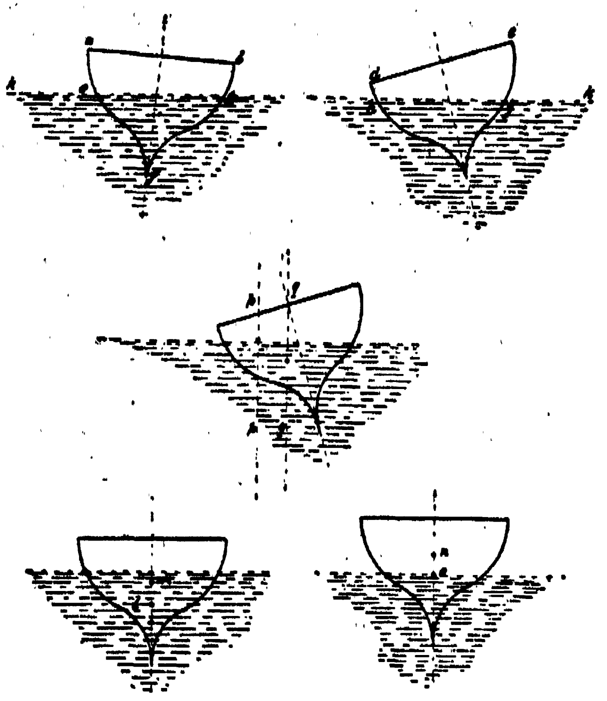


Fig. 6.

We have elsewhere in this Journal pointed out to the young reader the importance of considering all the conditions or circumstances connected with mechanical work, as these may bring up points which must be attended to, modifying more or less the application of a principle which in itself is sound, and which dictates sound work as a general rule. The value of this caution is exemplified in the case now under consideration, of the stability of ships and vessels. Essentially necessary for the due working of these, considered as carriers of commodities across the seas, still there are some modifying considerations or conditions to be taken into account. For vessels used on quiet inland rivers and in canals, where the wave influence or force is reduced to a minimum, the amount of stability cannot be too great,—at least, no practical harm will be done by having perfect stability. But perfect or great stability in a ship, while it gives steadiness in one condition, brings about an evil in another condition of circumstances. For a ship with great stability is of necessity one which "rights itself" quickly; and quick "righting" with adverse and frequently repeated pressure or forces, as of wind and waves, is simply quick 'rolling." Now, as rolling in one direction throws, so to say, a certain number of straining forces upon the materials, wood or iron, of which the vessel is constructed, any quick return from this direction, throwing the straining forces in another direction, gives rise to what may in one sense be called a new series of straining forces, which are very dangerous or damaging to the structure. Easy rolling is therefore a point to be aimed at; and from what we have said, this can only be gained by the sacrifice of a certain proportion of the stability of the ship. The giving way to the waves, or rather the way in which a ship's motion coincides with the motion of the waves, is under certain conditions a point to be aimed at in designing a ship; and this is always a characteristic of a stable ship. But in rolling, if the ship recedes from the wave which causes it to heel over to one side at the same speed as the wave advances—in other words, keeps time with the wave—it is obvious that a succession of waves will tend to increase the rolling, as each of them brings up its own heeling-over force. To avoid this, it is necessary that the speed of, or the time in which a ship rolls from the waves, shall be less than their speed—in other words, the ship must roll more slowly than the waves follow her or press upon her side. Now, from what we have said, this can only be gained by sacrificing a portion of her stability, although the way in which the cargo is stowed away and the general weight of the ship itself is distributed over its whole structure affects also this slower rolling, or the time or speed of its rolling. The surface of the water, or the plane of flotation, is not always level—indeed, out at sea and in anything like rough or heavy weather, this plane, so far from being level or horizontal, as at *d e* in fig. 5 (*ante*), is, as a rule, more or less inclined, giving a sloping surface as at *a b* or *c d* in fig. 6. The tendency of a ship to keep upright in water, which may have its surface either horizontal or level, as at *d e*, fig. 5, or sloping, as at line *a b* or *c d* in fig. 6, has been called its stiffness, as contradistinguished from that tendency to keep truly upright in rough-surfaced or wave-lashed water to which the name of steadiness has been given.

Points connected with Floating Vessels or Ships other than Heeling-over and Rolling Motions.—The "Pitching" Motion.

We have hitherto been considering the motions of a ship in relation to her cross or transverse section. This motion, which is from side to side, alternately depressing and raising one side along the whole length of the ship, as is well known to every one who has been at sea, goes by the name of "rolling," and can be conceived of as a movement of vibration or oscillation, on an axis which runs from end to end of the ship, at right angles to the line of cross section, and placed at some point on the vertical line of that section. But there is another motion in vessels in rough, or roughish, water at sea, better because more painfully known to those who are afflicted with what the French call the *mal de mer* (literally "ill or evil of the sea"), or we "sea-sickness," and to this motion the name of "pitching" is applied. In this the bow—and conversely the stern—of the ship is alternately raised and depressed; the motion being a longitudinal vibration or oscillation on an axis at some point midway between the bow and the stern. This motion of pitching is generally considered and described as a single motion; but in the technics of ship building it is described as of two kinds of oscillation—the term "pitching" when used in a general way including the two, or being a complete or doubled oscillation. This is correctly based on the phenomena of pitching, which embrace first a depression or lowering of the bow of the ship and a corresponding raising of the stern, to which single oscillation the term "pitching" is alone applied; when the converse oscillation takes place, the stern being depressed or lowered and the bow raised, the term "scending" is used. What is called the "trimming" of a ship is so disposing of her load along the *length* of the ship that she will float "on an even keel," or otherwise have her load so disposed in relation to her length, that the stern may be more depressed or float deeper in the water than the bow; in this case she is technically said to be "trimmed by the stern." In the converse case she is described as being "trimmed by the head." As a rule the "trimming by the stern" is that which in the practice of lading a ship is adopted. In connection with the points noted in this and the preceding paragraphs, there are other definitions to be given, such as of "metacentre," and sundry practical circumstances connected with the trimming of ships to be described; but all these will come up for consideration in due course, and in their appropriate places and paragraphs. Meanwhile we proceed, as forming part of the general introduction to the special points of the actual work of construction of the boat and ship builder, to give remarks on points of great interest, such as the mode in which vessels are steered or guided so as to take certain courses desired; and by which ships are propelled through the water by the use of sails. In connection with these there are many points, of interest as well to the general mechanic as to the boat or the ship builder. And the first to which we shall direct our attention is

Certain Points to be considered in relation to the Propulsion of Boats by Oars, of Vessels by Wind acting on Sails, by Paddles and Screws, and to the Steering or Guiding of Floating Vessels by the Helm.

As closely bearing upon the important points connected with boats and ships named here, it will be necessary for the young reader to take into consideration certain points connected with forces and motion. In the paper entitled "The Technical Student's Introduction to the Principles of Mechanics" he will find the different kinds of motion described as produced by one force only, and that acting in one direction. If there be more forces than one, but all act in the same line of direction, the extent and effect of these forces in producing motion will be equal to the sum of these forces. If they act in opposite directions the two forces will tend to destroy each other, and if equal in amount will neutralise
other, so that the body will remain at
being produced.

THE IRON MAKER.

THE DETAILS OF HIS WORK AND THE PRINCIPLES OF ITS PROCESSES.

CHAPTER III.

WE concluded the last paragraph in preceding chapter by remarking that the early make of iron was of the class now known as malleable or wrought. This there is good reason to believe now and then took the form of steel, as it is very probable the iron makers of the day occasionally stumbled on one of the modern methods of making this more valuable product. When we come to describe the details of the methods of modern metal making, we shall see, indeed, that the early masters could not at times prevent the reduced ore assuming the form of steel. That the iron produced as a general rule was of the first quality of the wrought or malleable class is beyond a doubt; it could scarcely, indeed, be otherwise, for the workers were compelled to use the finest ores for the simple reason that their appliances prevented the use of inferior qualities; and so slow was the process, such as it was, and so limited was the extent to which the reduction or smelting was carried out, that little in the way of impurity remained in the iron withdrawn from the furnace to deteriorate its quality. But the very limited reduction or smelting which the early workers could only secure was itself the cause of the scoriæ or cinders left over from the process being rich in metallic products. Hence, as we have hinted at, their utilisation was long centuries after taken in hand, by which much of the contained metal was reclaimed.

Malleable, Wrought or Hammered Iron the Form in which it was Early made.—Introduction of Cast or Pig Iron.

This, the original and long-carried-on method of the early iron makers—by which malleable iron was produced of a quality such as we now should class as wrought iron of the finest class, approaching very near in quality to what we now designate as "mild" or "ingot" steel, the product of the new processes of Bessemer and Siemens, described in the separate paper entitled "The Steel Maker"—was carried on in this country up to the reign of Elizabeth. That form of iron which is popularly and very generally known as cast iron—but amongst the trade as "pig iron," for a reason hereafter stated—was very likely introduced early in the reign of that celebrated queen, and probably carried on for some time, because we find the first recorded statement concerning the art tells us of cast iron used as a substitute for bronze in the manufacture of guns or ordnance. It is curious and suggestive to note in passing that the primary inciting cause of the discovery of new processes, or of the application of new machines or appliances, has been one or other of the many requirements of the art of war. Our readers are well aware of the fact, for example, that since the year of the great Exhibition of 1851—that year which most men hailed and believed would be the advent of a new era of peace—there has been a remarkable and a continuous development of the arts and sciences in the invention and manufacture of materials of war, in ships, guns, and arms of all kinds.

The art of cast-iron founding by the end of the reign of Elizabeth had reached so far in the way of progress that furnaces were in use of such (then) large dimensions as to be capable of producing from fifteen to twenty tons per week. When we state that many furnaces now in use are able to produce with ease five hundred tons and more per week, the reader will be anxious to know the method by which that vast produce is created and maintained from week to week so long as the furnace is "in blast," or "in work," and to become acquainted with the improvements which have led up to the realisation of such enormous results. All these details will come in due course before us; meanwhile it is almost unnecessary to state that those improvements were but few and far between in the earlier days of the industry, and were practically fewer still through the strong opposition which they encountered from the trade. For one of the valuable lessons to be learned from a study of improvements in the arts and sciences is that the first thing which an inventor or improver has to do is to overcome trade prejudices and business dislikes, and that it is frequently much more difficult to overcome those than it is to conquer the difficulties attendant upon the perfecting or introduction of their invention or improvement.

The history of the iron trade affords, perhaps, the most striking exemplification of this melancholy fact: one which, although not so powerful in its influences as in former days, is for the sake of true progress in the arts and sciences all too powerful still. So powerful that it affords, perhaps, a cogent reason for cherishing but little hope that the true relationship between the members of an established trade and those who propose to improve it will soon be recognised and acted upon in the spirit which alone can guarantee for us as a people that progress in the arts and manufactures which is such a powerful ministrant to individual and national prosperity.

Coal as a Fuel in the making of Iron.—Lessons to be derived from a Brief Glance at the History of its Introduction.

We have said in a preceding paragraph that some of our readers, not acquainted with the details of the iron trade, would express surprise that the difficulties in the way of carrying on the manufacture, arising from the want of wood, which yielded the charcoal, at one time used only as the fuel required in the reduction of the ores of iron, would be overcome, and easily, by the use of the common coal of which we now have such enormous bulks. The reader of this class must remember that, plentiful as coal now is and has for long been, and comparatively easy as it is to procure it from the mines, or coal *pits* (the term "mine" being rarely applied, although coal is mined precisely as other minerals—see the paper descriptive of coal pit working), things were not always so. It was some time before coal was used, some time longer before it became known that it existed in such enormously vast deposits in many districts of the kingdom, that it was even till comparatively recent times considered, even by scientific men, to be inexhaustible. Longer time did it take for us to be able to avail ourselves of those vast supplies; and had it not been that precisely at the time wanted the steam engine came to the aid of the coal-pit proprietors, the supply would have totally failed.

Coal in some places crops out quite to the ordinary surface of the ground; in others comes up to within an easily reached distance from it; but in the majority of cases it lies in strata at a considerable depth from the surface. In early times, after its value as a fuel was known, mechanical means and appliances at the command of the coal workers being of the simplest, and even in that condition difficult to be made, coal for some time would be got by digging for it from the surface, just as one would dig for chalk, lime, or marl; and as the excavations for those materials were familiarly known as pits, the term was obviously from the earliest times of coal-getting applied to the diggings used to come at it, and is still much more frequently used, as we have stated, than the more dignified name of mine. About the end of the thirteenth century coal was obtained in comparatively large quantities from the pits at Newcastle-on-Tyne—the earliest, at least the first important seat of the coal trade—from which port large bulk was exported to what was then called the Low Countries, now Belgium and Holland. This export was carried on principally to supply the iron workers with fuel for the production of iron, wood being over a large area of this part of the Continent as scarce as it was with us. One would think that this fact of its being so employed would have naturally struck the iron masters of this country as one as valuable for their trade purposes as it was for the makers of the Continent. But the reader who supposes that this would be the inevitable result of the circumstances then existing has but little knowledge of the economical history of our great branches of industry. Our iron makers of the period referred to not only refused to avail themselves of the help out of their difficulty in the matter of a non-supply of (wood) charcoal, which coal was thus proved by other makers to give them, but they went further—no doubt to reconcile their consciences to the stupidity of their conduct, and maintained that coal could *not* be used for iron making in any way. We have not yet quite learned to be wise as to the losses resulting from folly such as this, for it was but the other day, speaking comparatively—for years in the life of a great people are but as a day to the individual—that our own iron masters adopted an improvement in working which for years they had maintained could not possibly act, notwithstanding that iron masters of the Continent had used it with great economy for years. Examples of this method of doing business, if not numerous, at least very striking, may probably be given as occasion offers in the pages of our work yet to come. We have now reached that point in the history of the iron trade which, however, affords perhaps as striking an exemplification of folly of this kind as can be offered by the history of any branch of national industry. A most striking example, truly, for the folly or the sin (and it was both) retarded the prosperous progress of the nation, and kept thousands out of profitable employment for a long, long period of years; and last, if in the opinion of some it be the least, result of such a miserable train of unhappy circumstances, it utterly ruined a most deserving man, and breaking his heart, prematurely killed him. The whole circumstances, if recounted, would, as indeed they do, form one of the most romantic and touching episodes in our national history.

Notes on the Early History of Iron Making with Coal as a Fuel.

It may easily be supposed that with a people so naturally enterprising, so curious in prying into the secrets of nature, of such an inventive and ingenious turn of mind as we have from the earliest times been, and are now more so than ever, there were those amongst them who were by no means satisfied with the rough-and-ready, and assuredly, in every sense of the term, rude way in which so many decided that for one reason or another, and each and all deemed to be true reasons, coal was *not* applicable to any of the purposes of iron making. The continued scarcity of wood, and, as may be supposed, the gradually increasing supplies of coal, compelled more attention to be paid to the subject, to see whether or no coal could, after all, be used by the iron makers of this country—as, beyond all doubt, it was then, and for some time had been, used by the iron makers of the Low Countries abroad, as witness the large supplies of Newcastle coal they would have sent them for this very purpose. The first recorded trial of coal as a fuel for smelting or reduction of iron in the trade or branch of cast-iron or pig-iron making—which by this time had become an established industry—was that made in the year 1612.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

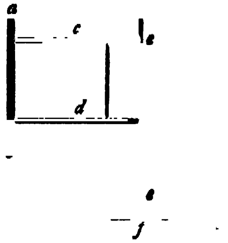
TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

69. Bessemer Steel Castings.

WE concluded our last "note" (No. 63, p. 339) by alluding to the fact that Sir Henry Bessemer had so anticipated the coming necessities of his process that he had at an early stage of his career as the inventor of the converter system, devised and indeed patented a method of mechanically agitating the molten steel before it was turned into the ingot moulds. Those who are acquainted with the career of Sir Henry Bessemer as a metallurgist know well a very striking feature in his character—namely, his mechanical prescience (we use the term here with all becoming reverence in view of Him who is alone absolutely prescient), or the way in which in bringing out his great invention he was able so to foresee or anticipate the mechanical necessities of the process at its various stages that, as it left his hands at its final working stage, it was complete practically in all its departments. So much so was this the case, that although improvements in detail have no doubt been effected—as the great improvement in the converter which was due to that undoubted metallurgical genius, the late Mr. Holly, of America, but too early taken away from the service of his own and this country—still the system of working the converter steel-making process remained for a long course of years, and still remains virtually, the same as it left his hands. And even in this, which may be said to be the latest phase of the process—the agitating or mixing the molten steel as it passes from the converter, and before it is "cast" into the "ingot" or other forms—Sir Henry Bessemer may be said to have in his own mind predicted what would happen at a much later date in the history of his process; and not only to have done so, but anticipated the certain realisation of his prophecy by inventing and patenting at a very early period of his career as a metallurgist a method of mechanically mixing the molten steel. For, like all truly great inventors or discoverers, and unlike some others who are not great, Sir Henry, while maintaining the accuracy of his views in the main, and the value, as a whole, of the products of these, was not backward in admitting that improvements in certain points could be made, and were indeed necessary to be made. And this defect in his steel, which has been specially alluded to at an early period of this series of notes—and in one sense may be said to be the reason why we have taken them in hand on behalf of our readers—namely, its lack of uniformity or homogeneity—has been admitted. In Sir Henry's early patent he described a mechanical agitator revolving in the molten metal, under cover of a skin, so to say, of molten slag floating on the top. By this means the air was excluded, so that any changes in the condition of the metal would be due to the agitating or stirring only, and not to any combination brought about or changes induced by the action of the atmosphere. It certainly is greatly to be regretted that this proposition of Sir Henry Bessemer's was allowed to die at once after birth, or, as the phrase is, was still-born. It may be taken as an addition to the very long list of inventions before their time—or rather, it would be more correct to say, it was one of those inventions which were really required, and which could have been at once utilised, for the necessity for its use then existed; but of which it is to be said that they were not used, the necessity to use them having not been taken up and believed in by those most interested. And it is difficult to estimate the loss which the public has sustained for so many years through the existence of this peculiar condition, which seems to be the normal one of a certain class or classes of it. Certainly in this particular instance of Sir Henry Bessemer's too early introduced or patented invention, Mr. Allen is quite justified in saying that had it been adopted at an earlier stage in the history of the process, "much of that feeling of uncertainty in the material, and the general impression of the want of uniformity, would never have arisen; and many of the fancy tests now imposed (on makers) by consumers would not have come into fashion." Now that the method of mechanical mixing, or agitating of the molten steel as it is at first turned from the converter, has been re-introduced, and in principle the same as the earlier contrivance patented by Sir Henry Bessemer, we shall see whether that indifference to a well pronounced and successful mode of working will be exerted, or rather—for there is not much exertion in positive apathy—brought to bear upon the method, so as to keep it practically inoperative, or if not precisely this, at least to a large extent idle. Glancing at the history of inventions and processes is not merely the gratification of a natural curiosity. Much can always be learned, if only there is a desire to learn the lessons which it teaches, having a very close connection with the details of any business practically carried on, and which is therefore highly suggestive to the mere technical student, who may be looking forward to the time when he may himself be in "business," to secure success in which he will find, as so many have found before him, requires a greater number of points to be attended to than many—unfortunately for themselves—seem inclined to consider necessary. To use in this connection a curious North of England popular phrase, the full suggestive force of which it takes a north countryman to understand and thoroughly appreciate, "It takes a man to look more than *one way* for Sunday."

The form of mechanical agitator for molten Bessemer steel, which has been now introduced so successfully into practice, is as simple as it is effective in operation. It may be described in a few words by the help of the annexed simple type diagram. Let the thick line *a b*, to the left, represent the wall of the converter shed. This carries a strong iron bracket, stretching out horizontally over the converter pit, the upper and lower parts of which are represented by the lines *c* and *d*. This bracket carries at its outer extremity the bearings in which a vertical shaft, *e e*, works, this being made to revolve by bevel gearing. The lower end of this shaft *e e* carries the agitator, represented by *f*, and which takes the form somewhat like a two-bladed screw-propeller, in which a slight twist is given to each blade. This simple mechanical device is a fixture, not only in the sense of being stationary at and above one point in the circle of the converter pit, but also in the sense that the vertical shaft, *e e*, with its stirring blades, *f*, has no vertical movement up and down, as in the direction from *f* to *e* or from *e* to *f*. The agitator, therefore, cannot be lifted up and then dropped into the mass of metal to be stirred, carried by the ladle filled from the converter. This difficulty is got over in a very simple way; for the machinist and engineer is ever fertile in expedients, and if he cannot make the "mountain go to Mahomet," he compels "Mahomet to go the mountain." The ladles used to hold the molten metal received from the converter are, as those know who are conversant with the working of the Bessemer steel-making process, made to sweep round or command the area of the ingot pit by an hydraulic crane. The normal level at which the ladles are carried round is lower than the level of the blades, *f*, of the mechanical agitator, as roughly shown by our type illustration.



The hydraulic ladle, then, brings round a ladleful of molten steel to a point in the sweep of the ingot pit immediately under the blades of the agitator. The attendant stops, by turning one handle, the progress of the crane, arresting the ladle motion, so that the blades are above the centre of the mass of metal; by turning another handle he makes the crane mechanism *raise* the ladle—with, of course, the necessary result of forcing the blades, represented by line *f* in our type diagram, into the mass of the metal, and to the depth required. The driving mechanism is then put in gear, and the shaft *e e* is made to revolve at the rate of one hundred revolutions per minute. When the stirring or agitating has been done sufficiently, the crane mechanism is again put in operation; the ladle is lowered till it is clear of the agitator, and assumes its normal level of circular sweep. It is then moved round till the discharge orifice, with its stop valve or plug, is above the orifice of the ingot mould, when this is filled with the well-stirred molten metal. The enormously high temperature of the molten steel in the ladle would soon destroy the iron blades, *f*, and shaft *e e* which carries them; but to protect them they are covered with a composition known as gannister or with loam. This covering has to be done with the greatest care, as any falling off of it from the parts which it covers would be fatal to the "life" of the apparatus. The cost of the agitating process is so trifling that no appreciable amount can be set against it, so that practically it is debited with *nil*. And the time taken is also so short that there is no inconvenience attendant upon the use of the apparatus. Having thus so far gone into the process of molten steel mixing, we are prepared in our next to take up the leading points connected with the "castings" made of this mixed or stirred steel, to be used for various constructive purposes, and about the constructive strength or value of which there is such a wide diversity of opinion amongst practical men.

70. Calculating Surfaces and Contents of Pieces of Metal or Wood, when Fractions are given in the Dimensions.

The young mechanic has frequent occasion to know the superficies or area, or the cubical or solid contents of a piece of metal—as a beam, for example—when fractions of feet or inches are given in the dimensions. The calculations are easy to be made when the decimals of the fractions or parts are known. We give, for the benefit of the young mechanic, decimal parts in the following tables: A "being the decimal equivalents of parts of a foot in inches and eighths of an inch"—and B the "decimal equivalents of the parts of an inch in thirty-seconds from 1 to 31." The use of these tables is simply explained. To find, for example, the area of a given surface in square feet, of which the length is 10 inches by ⅞ths of an inch, find the decimal of 10 in Table A = ·833, and of ⅞ths = ·073; then ·833 × ·073

= the area. To find the cubical or solid contents of a piece of metal measuring $10\frac{7}{8}$ths inches in length by $6\frac{3}{32}$nds inches in breadth by $\frac{22}{32}$nd parts of an inch in thickness—that is, between $\frac{5}{8}$ths and $\frac{3}{4}$ths of an inch. Take the decimal equivalents of the above fractions of an inch and multiply them together or into one another, and the quotient is the cubical or solid contents. Thus $\frac{7}{8}$ths decimal equivalent = ·875, $\frac{3}{32}$nds = ·093, $\frac{22}{32}$nds = ·687; then 10·875, or the length, multiplied by 6·093, the breadth, and ·687, the thickness, gives the contents.

TABLE A.

Inches.	Equivalents in Decimals.	Inches.	Equivalents in Decimals.
⅛	0·10	3	·25
¼	·020	4	·333
⅜	·031	5	·416
½	·041	6	·5
⅝	·052	7	·583
¾	·062	8	·666
⅞	·072	9	·75
1	·083	10	·833
2	·166	11	·916

TABLE B.

Fractions of an inch in thirty-seconds.	Equivalents in Decimals.	Fractions of an inch in thirty-seconds.	Equivalents in Decimals.
1	·031	17	·531
2	·062	18	·562
3	·093	19	·593
4 (or ⅛")	·125	20 (or ⅝")	·625
5	·156	21	·656
6	0·187	22	·687
7	·218	23	·718
8 (or ¼")	·25	24 (or ¾")	·75
9	·281	25	·781
10	·312	26	·812
12 (or ⅜")	·375	27	·843
13	·406	28 (or ⅞)	·875
14	·437	29	·906
15	·468	30	·937
16 (or ½")	·5	31	·968

71. The Action of Lime as a Mortar or a Cement.

A correspondent sends us the following as an expression of his views on the subject. When a mixture of lime and sand with water in the proper proportions is placed between two stone or brick surfaces, after the lapse of time a cementation takes place—that is, the mixture placed between the surfaces hardens, and the latter are firmly cemented together, and with such strength that, as your correspondent "F.G.S." remarks, "the solid stone or brick itself will often yield to strain sooner than the hardened mortar." Now, I have always understood or taken for granted—because I don't remember ever having read of such an explanation—that the action that takes place is as follows: The silica contained in the sand unites slowly with the lime, forming one of those extremely hard insoluble compounds well known to good chemists, called *silicate of calcium*, until in course of time the whole of the mortar is converted from a mere mechanical mixture of lime, water, and sand into a solid mass of calcium silicate. Now, this would appear to explain the hardening of the mortar, but in no wise does it touch upon the question of the *adhesive* properties exerted by that The simplest explanation, I think, of this material latter point is this: that the portion of the lime immediately touching or lying on the brick unites with the silica contained in the latter, thereby forming an intimate, solid connection—in fact, a fusing, as it were, of hard mortar into the brick. In the case of cementing stone containing no silica the action would be that a portion of the sand of the mortar unites with the lime contained on the surface or face of the stone.

72. Luminous Paint.

Of late years efforts have been made to introduce into general use paint to which the property of giving out light in the dark had been imparted, by admixture with sulphide of lime. This latter salt is readily obtained by heating a mixture of lime and sulphur to bright redness. On exposure to light it absorbs a certain amount of the rays, and gives them out again when taken into the dark, appearing luminous or phosphorescent. Articles covered with oil-varnish paint, made with sulphide of lime, appear luminous in the dark, for a length of time dependent upon the duration of the previous exposure to light. It was hoped that extensive practical application could have been made of this principle. Lamp-posts and gates, bridges, and the tail end of trains, life sea-buoys, and lighthouses, were painted with the new luminous paint—all being rendered perfectly luminous and visible in the dark, the amount of light evolved being in each case proportionate to the length of time previously exposed to light. Notwithstanding these results, luminous paint, though employed to a limited extent, has not found the extensive application anticipated for it, owing chiefly to the fact that in dark winter nights, when most needed, the luminosity will be less, owing to the darkness of the days; whereas in summer nights there will be great luminosity when less need of it. And it need hardly be observed that in such cases it is most important that it should be *dependable* or reliable in its action, as otherwise it might lead to those very inconveniences or accidents the prevention of which is the object of its use.

Sulphide of calcium or lime absorbs more light when warm, and gives it out again more readily. Either daylight or sunlight or artificial light serves to excite the phophorescent properties of this substance. It should be remembered that luminous paint must contain no lead compounds, nor must it be laid in contact with anything containing lead, as the black lead-sulphide would then be gradually formed.

It is hoped that luminous paint may yet be extensively employed in the many directions in which it is, beyond doubt, applicable. Next month we intend to give an account of its present use and its future prospects.

73. Treatment of Rose Plants in the Flowering Season for the Insects.

It is only to one point in connection with this the "Queen of Flowers," as it is deservedly called, that we propose devoting a paragraph, and this is an important one, as all who cultivate the rose know well—namely, the prevention of the ravages of insects. Of these the chief, if not the only one demanding extremest care, is the Aphis, known popularly as the "green lice." Amongst the many valuable, but not always valued, lessons which the cultivation and care of flowers of all kinds teaches, there is none perhaps more striking and salutary in the influence it has upon the *morale* of the flower grower than that of patience and persistence in the doing of necessary work. And we doubt if this most valuable attribute is more thoroughly tested in all the wide and varied range of flower culture and care than the work to be done in connection with the Rose, at that season to which our note refers. And unless this virtue be exercised to the full, we may say at once that success in bringing forward the roses to that perfection which all like to see will not be secured. Minute as the insects known as the green lice are, considered individually, it is amazing how great the extent of the mischief which but a few will do to a plant in a remarkably short space of time. Nor is the rapidity with which they multiply a less marked or a less annoying feature of their existence. If the amateur rose grower—for it is to the gardeners of this class our note is addressed—through any cause—illness, laziness or indifference—ceases to pay attention to his plants for but a single day, he knows but too well that he will have to suffer—or rather his plants will —no small loss as the result of his absence, or as the penalty of his neglect. To one who for the first time comes to the work of rose culture and care, and to an observation of all on which its success depends, nothing will be more surprising than to note the extreme rapidity with which the insects increase and multiply. He will have left a plant which he believes to be almost free from them but a few hours, and on his return he will find branches and buds literally alive with them. And great will often be his disappointment, should he be called from home for but a day, to find on his return some "precious buds," which promised to give him some splendid roses, half devoured, and hopelessly ruined. The surprise, indeed, is to the novice very great, how so small, so insignificant-looking an insect, can do so much mischief in so short a time. It is a fine example of what small efforts persistently continued can do; and it affords an excellent lesson, inasmuch as it is only by a like persistency in the carrying out of preventive measures that the mischief the insects may do can be prevented. 'What is the preventative?' the novice may ask. More correctly the question might be, 'What are the preventatives?' for they are more than one. With a certain reservation it may be said that their name is legion. We do not purpose giving even the names of the best known of these, but simply to confine our notice to one which has now been tried for some seasons, not only with roses, but many other insect-plagued plants, with such marked and uniform success, that we never think of using any other. This is nothing else than carbolic acid—a liquid, fortunately for those who have not much cash to spare, as cheap as we have found it to be successful. The acid we use is the ordinary, or what is called crude (that is, not refined) or commercial. As we have said, it is very cheap: two-pennyworth we have found to do a very large amount of plant-clearing work, with a good deal to spare for battles with the slugs or snails, which do such woful damage to such crops as vegetable marrows, kidney-beans when starting, and to strawberries. The crude carbolic acid being very strong, and being a poison, requires to be kept carefully under charge, and should be diluted. The process of preparation is very simple, and demands no great nicety of proportions. We generally use an ordinary-sized teaspoonful to a quart or rather better of water. The water is applied boiling, or at least very hot; the acid being placed in an earthenware jug, and the hot water poured over it and this from some height above the jug, so that the agitation will mix the acid well with the water. The mixture is ready for use as soon as it is quite cold.

The best way to apply the mixture to the plants is in the form of a spray. For the amateur, who is not supposed to have very many plants to keep in order, one of the small blowpipe scent or spray distributors will be the best, as it certainly will be the cheapest—costing as it does but a few pence. For distribution on the larger scale, a small pump with a spray nozzle will do excellent service. We have such faith in the efficacy of dilute carbolic acid water in getting rid of all kinds of insect plant-plagues, that we believe if it was applied by pump and spray nozzle to the hop plants, the losses which vex the souls and impoverish the pockets of hop growers, of which we hear so much, would be largely if not wholly avoided. To return to the work of the amateur in clearing his rose plants from the insect pest by means of a small or as we call it a toy spray distributor: while its purchase is within the means of nearly all rose cultivators, its use is not within the compass of the lungs of all. To blow the spray upon one plant may be easily enough done; but if half a dozen plants, and those of moderate size, have to be operated upon, even a strong-lunged amateur gardener will find himself sufficiently tired of the work of blowing the spray. Some are so tender in their lungs that they cannot, and indeed dare not, attempt the work of "spraying" even a small rose-tree. In such a case one has to resort to other means of applying the dilute carbolic acid water. We believe there is a form of small sick-room or drawing-room spray distributor, worked by means of a hollow vulcanised india-rubber ball or sphere. We have not tried this, and have had no occasion to do so; having in the first instance provided ourselves with an ordinary blowpipe sprayer, and nature having kindly provided us with such a powerful "puff," as one of our young folks persists in naming it, that with very brief, judiciously arranged pauses or intervals, we can "doctor"—another juvenile term—a goodly number of plants without being much if in any way distressed.

If the plants are treated in time—that is, before they are taken a thorough hold of by the insect plague—the spraying is very effective; and those who use it for the first time will be amused or gratified at the way in which the insects will "drop" from the plant the moment they are touched by the spray. But if through neglect, laziness, or indifference, or perhaps an enforced absence of a day or two from the pleasures which plant culture and care give in large measure to all lovers of flowers, the insects get a thorough hold of the plants—we have found that repeated applications, or rather a lengthened and continous single application of the spray, is necessary before the insects are dislodged from the plants. And this lengthened spraying, from what we have said above, is not within the compass of every amateur gardener's lungs to give. All this points to the amateur beginning very early in the season to look after the insects. There is nothing like dealing with them in detail; for in no case is the truth conveyed by the proverb "a stitch in time saves nine" more enforced, than in that of the insect plague of rose plants. The two or three of to-day, if not sprayed off, will in two or three days have multiplied to dozens and dozens. Their rapid increase is marvellous, and so also is the way in which so many contrive to keep on to the branches or twigs. We have seen them many a layer thick, till a slender twig bulges out to the size of a thick one. And the rapidity with which such individually tiny insects get rid of, or eat up, leaves and buds, and destroy or impair the vitality of the branches, is no less surprising.

When plants, then, are so thickly infested—we were about to say incrusted, and the term is after all graphically expressive—with the insects, the very thin and attenuated spray—it is more like a vapour than a liquid shower—acts too slowly upon the plague: more vigorous measures have to be taken. There is a way of deftly flirting with the fingers drops of the dilute carbolic acid water in such heavy showers, so to call them, that the application is more effective than the spray; or a light sponge may be used to wash or brush off the insects. But we have found no method so effectual as using the fingers—dipping these into the carbolic water, and gently rubbing off the insects. Nothing can exceed this delicacy of touch, and a very little practice will enable one to get so deftly through with the operation, that he will be surprised to find how short a time is required to do so much. No doubt the method has its disagreeables. Some, indeed, would say that it is essentially and altogether disagreeable. In the first place the fingers will for some time after the work is finished have an odour which is very suggestive of tar. But this is not disliked by some, and at the worst is not so very bad. In the second place the method involves a brushing off and a crushing up of vitality or life which we freely confess is at the first experience of it anything but pleasant. It has more than once so shocked the susceptibilities of delicate friends that they have "wondered" or been "surprised" that we could do such a thing—with a double emphasis on the "could" and the "such." To which our reply was invariable—"Well, it is not pleasant, but, much as we dislike the process, we love our plants and the roses they give us too well to make us grudge doing such an office for them." And we are free to confess that it is only the true flower-lover who would undertake the work and give patiently the time to it which its proper doing demands. And if a little sacrifice of feeling is feared, and some time and trouble are grudged, there is nothing more to be said, save this —that the so-called love of flowers cannot be very strong. And after all the labour gets lighter every day. For whether it is that, like rats, the insects leave places where a warfare of continual disturbance is kept up, or whether it is that the leaves and branches of the trees or plants get so impregnated with the peculiar odour of the carbolic acid, we do not here pretend to decide; but the fact we can vouch for is that each day the plague is lessened, till at last a point is reached when an occasional application of the carbolic water only is required, and in some instances even that may be dispensed with. We have seen enough in the case of other plants—such as vegetable marrows—as well as in that of roses, to convince us that there is something in the carbolic acid water peculiarly obnoxious to insect life. And on the other hand this valuable peculiarity is not lessened by any evil influence which the acid exercises upon the plants themselves. On the contrary, we have abundant evidence that there is something in it which has a good or healthy influence upon vegetable growth. Many a time, when some favourite plant has been showing symptoms of being out of condition, have we brought it quickly back to vigorous life by one or two spray applications of the acid water. Not once, but often, have we returned home after an absence more or less lengthy, to find our rose-trees so neglected as to be so infested or incrusted with insects that to save them or to get flowers from them that season seemed to be altogether hopeless. But the labour required to give them what at the best was but a very slender chance indeed of recovery was never grudged. As well it might not have been, for in no instance was the labour lost,—quite the reverse of that, in the fine healthy plants and the beautiful roses we have had. And we confess that not seldom have we been surprised at what the application of carbolic acid water has effected. We have had buds actually and as we thought hopelessly eaten into by the insects, and which under ordinary circumstances would not have recovered, but rotted or decayed away, actually restored to such healthy life as to yield roses which might be pronounced fine. This often to the surprise of others, as well as to our own. We should be very much gratified if what we have given on this subject will induce some hop-grower to try the dilute carbolic acid water on his plants this year. We feel somehow pretty well assured that the application will be successful—infinitely more so than the water washing or sponging which is tried; and the acid is so cheap that the cost of the carbolic application will not greatly exceed that of ordinary water. We hear, season after season, of hop growers earnestly wishing for rain to come to wash off the insects from their plants. They have here a chance of making artificial showers of a liquid which, to say the least of it, promises a good deal in in the way of stopping the ravages of the insect plague which every year destroys so many of our hop flowers.

74. Topping of Garden Beans.

In giving our various notes on gardening, we do not, as a rule, intend to issue them so as to be "seasonable,"—that is, in the sense of being published at or about the time when they can be applied in practice. We do not profess to give a "calendar of work" in these notes. Our aim is simply to record a number of facts and figures which in time will form a body of information, which, though given in detached paragraphs, will be more or less useful in a practical, but in all cases of a suggestive character. The present note will, however, be published so as not to be very far in advance of the period when topping of beans will be valuable. The mere name will convey to most the nature of the work—which is to cut off the top or upper part of every beanstalk. But many, and even of those who have for long kept gardens and grown beans for family use, have no idea what useful purpose the process is to serve. We have met with more of this class than at one time in our practice we should have deemed likely to exist. If the reader who has not hitherto paid attention to the subject will take notice, next time he has a plot of garden beans—"broad" or "Windsor"—that at that stage of their growth about the period when the plants are coming or about to come into full flower, seldom later on, when the flowers have faded and the bean pod just formed, the tops of the plants begin to be spotted over with very black marks. If allowed to go on, these will increase till the black covers the whole head, and extends downwards along the stem. These black marks or patches are minute insects—so minute that thousands will be thickly clustered round a few inches of beanstalk. If closely looked at, what appear at first sight to be but some black-looking material or substance which has gathered upon the upper part of the plant, will be found to be in motion, the insects thickly clustered giving a movement not easily traceable in the single insect. These insects invariably attack the upper, the freshest and newest, and to them the sweetest part of the plant. If the original colony which takes possession of this part be allowed to rest there, the insects multiply so rapidly that they extend downwards till the whole plant nearly will be covered by them. The presence of these black insects, corresponding to the green aphides which affect and often ruin roses, simply means practical death of the plants, for the crop for which they are alone grown will be poor in proportion to their presence, and in some cases will be totally destroyed. The only way to secure the crop against this curse is to cut off the upper part or top of each plant as soon as the black spots or marks begin to appear. This may seem to be a tedious process, but it is much more quickly done than one would think; at all events, the gardener has only to choose between taking this trouble and having little, in many cases no crop. The topping may be done by nipping the heads off with the finger and thumb, but by far the quickest and most pleasant way is to use a large pair of scissors or shears. The severed heads should be collected and put in the manure or compost heap. All seasons are not alike as regards this bean pest, some being specially bad; but we do not recollect ever seeing a crop wholly free from it, and even in its lowest development the insect is too mischievous to be allowed to continue its ravages. No plant can be healthy when it is present. And an early look-out for the appearance of the insects should be given, as the period of their attack varies, and this chiefly from peculiarities of the weather and the condition of the plants.

75. The Metrical or Continental System of Weights and Measures now largely used in Technical Papers in this Country.

In paragraph No. 35 (p. 190), we have given a note on thermometric scales, and have there alluded to the fact that the decimal system of weights, measures and scales in use on the Continent, and generally known as the "Metric" or French system, it having originated in France under the auspices of the first Napoleon, has been largely and is being more and more largely used by scientific men in this country in their investigations and experiments, and in the formulæ deduced therefrom. This fact, together with that other suggestive one, that a large number of technical papers most valuable for our practical purposes are met with in French, in which of necessity the Decimal system is used, render it a matter of no small practical value to our readers that those at present in ignorance of should be made acquainted with the Continental Metric (Decimal) system. Its leading characteristics we propose to give in a series of paragraphs, of which this is the first instalment. The term "Metrical," which is the most commonly used term to denote the system, is derived primarily from the Greek word *metro*, which is the "unit" or base figure of the system. The term "metrical" given to it is, however, perhaps more widely, and certainly more popularly, supposed to be derived from the French word *mètre* (see Dissertation of the Technical Dictionary). The word *mètre* itself is the leading term in the tables of measurements, linear and cubical, and has a like relation to the general terms as our yard has to the general terms of our own measurements. From the yard the mètre in point of length varies some one-twelfth or thereabouts. The term "metro," which is the true base of the term metrical system, and which, as we have said, is its "unit," is the "ten-millionth part" of the distance between the North Pole and the earths' equator.

(*a*) "Measures of Length and Distance leading features of the Metrical System adapted to Linear Measurements."—The base of these measures is the "metre," the length of which is given below. The "multiples" of the "metre"—of course decimal in character—are 10, 100, 1000, and 10,000. All these are named or distinguished from one another by terms prefixed to the word metre—these prefixes are derived from the Greek language. Thus the multiple 10 of the metre has its prefix "deca"—a *Decametre* is therefore equal to 10 metres. The multiple 100 has its prefix "hecto"—a *Hectometre* is therefore equal to 100 metres. The multiple 1000 has the prefix "kilo," the *Kilometre* being thus equal to 1000 metres. The multiple 10,000 has the prefix "myria," and the *Myriametre* is 10,000 metres. The sub-multiples, or divisions indicating measurements less than the metre, are 10, 100, and 1000. These are named by giving prefixes to the metre—those being taken from the Latin language. Thus the sub-multiple or division of the metre 10 has the prefix "deci"—a *Decimetre* is therefore equal to the tenth part of a metre. The division 100 has the prefix "centi"—a *Centimetre* is thus equal to the hundredth part of a metre. Finally the division 1000 has the prefix "milli" given to it—so that a *Millimetre* is the one-thousandth part of a metre.

The relative values denoted by the prefixes are seen in the following table :—

Milli = 1000th part of the unit or metre
Centi = 100th part " "
Deci = 10th part " "
UNIT = 1 metre
Deka = 10 metres
Hecto = 100 "
Kilo = 1000 "
Myrio = 10,000 "

(*b*) "Equivalents in English lengths and distances of the above Metrical Measurements."

The Unit is the Metre, which equals 39·37 inches

Millimetre = $\frac{39·37}{1000}$ inches = ·03937 inches

Centimetre = $\frac{39·37}{100}$ inches = ·3937 inches

Decimetre = $\frac{39·37}{10}$ inches = 3·937 inches

Metre = 39·37 inches = 3·28 feet = 1·09 yard.*
Decametre = 10 × 39·37 inches = 393·37 inches = 10·9 yards
Hectometre = 100 × 1·0936 yards = 109·36 yards
Kilometre = 1,000 × 1·0936 yards = 1093·6 yards
Myriometre = 10,000 × 1·0936 yards = 10936 yards

(*c*) As a useful contrast we here give the corresponding table of English lengths and distances :—

12 inches = 1 foot
3 feet = 36 inches = 1 yard
5½ yards = 16½ feet = 198 inches = 1 pole, rod or perch
40 poles = 220 yards = 660 feet = 7920 inches = 1 furlong
8 furlongs = 320 poles = 1760 yards = 5280 feet = 21,120 inches = 1 mile

(*d*) The following gives in tabular form English measurements with Metrical equivalents :—

Mile	Furlongs	Poles	Yards	Feet	Inches	Metres
1 =	8 =	320 =	1760 =	5,280 =	21,120 =	1609.3149
	1 =	40 =	220 =	660 =	7,920 =	201·1644
		1 =	5½ =	16½ =	198 =	5·0291
			1 =	3 =	36 =	0·91438
				1 =	12 =	0·30479
					1 =	0·0254

In land surveying a linear measurement is employed called a "chain," the length of which is 66 feet; its Metrical equivalent is 20·116 metres.† A hectometre is 4·97 chains; a kilometre is 49·71 chains. In nautical practice a "knot" is equal to 1·15 miles or 6082·66 feet, and its Metrical equivalent is 1853·93 metres.

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* More correctly a Metre is = 39·3708 inches = 3·2809 feet = 1·0936 yard.

† In Square or Land Measure—which see in a future paragraph—the "chain" differs from this factor.

THE PRACTICAL NOTE-BOOK

OF

INDUSTRIAL SCIENCE FOR HOME STUDY

(26) We have elsewhere in this department of our Journal given a note on the relations of "solutions" of solid substances, which in the popular phrase are more or less easily melted in liquids or fluids of one kind or another. If a liquid, as water, dissolves a solid substance, say, as sugar, when the melting is completed the resulting liquid is said technically to be a "solution"; and in proportion to the quantity of sugar dissolved is the liquid said to be "saturated." The degrees of saturation are—like those of heat and cold—purely relative. Thus, in the case of solutions of sugar, one solution may be said to be sweet—even very sweet—yet it may be far from sweet in relation to another solution, which may be sweeter still—that is, have more sugar dissolved in it. In making solutions it will be observed that the liquid, as water, will, beginning with small weights of the substance, say sugar, keep taking up more and more of the sugar as the portions last put in are melted, the solution being sweeter and sweeter and becoming more and more saturated. But at last a condition of matters is reached when, however much of the sugar is put into the liquid, and however industriously the solution is stirred, the sugar will not be melted, but in a state of rest will lie at the bottom of the vessel, surrounded and mixed with water, but quite unmelted. The water or liquid seems to have lost its dissolving powers; it is not able, so to say, to carry a further load of the sweetening matter; it can no longer attack the sugar and make it give up its secretions. When a solution gets into this condition it is said to be "supersaturated."

(27) In Note No. 10 we made a remark or two upon gypsum, better known as plaster of Paris, and its value in the arts as a cementing material, and one also of great use in other ways, as in the casting of ornaments and the making of a fine hard plaster. But, valuable as it is, from the rapidity with which from a condition of a creamy or thicker paste it "sets" into a material as hard as stone, this very characteristic has its disadvantages; for not seldom does the plaster set before the work it is used for is completed, at least with all the nicety and finish which one may wish to give it. Hence a method is obviously desiderated of treating the gypsum so that while it still, when made into a paste with water, retains the property of "setting" or hardening, setting is so slowly done that ample time is afforded to use it and finish off the work to which it is applied with all the carefulness and necessary slowness desirable. Such a method we owe to the researches of a Continental scientist, of which the following is a brief description:—The method is, like many other improved modes of working different substances, very simple, and consists in mixing with the water and gypsum a portion of the dried root—pulverised of the plant well known as the marsh mallow. This, mixed with the powdered plaster of Paris, forms with it a species of fat lime, the setting or hardening property being only delayed, and not in any sense impaired. The softening properties of the marsh mallow are well known; they give, in fact, the name to the family of this well-known plant, of which there are many varieties, this name, *malvaceæ*, being derived from the Latin *malva*, and this from the Greek word *malache*, which itself comes from the Greek verb *malasso*, to soften. The softening property of the marsh mallow arises from the presence of a large percentage of mucilaginous matter, which distinguishes the whole family. The mucilage present in the marsh mallow seems to have a singular effect on the plaster of Paris. It can be moulded into any form, plain or ornamental; rolled into sheets possessed of considerable elasticity, and which, when hardened, do not break,—worked, indeed, in the many ways which a thoroughly plastic and tough substance admits of. For the ordinary purposes of cementing, the plaster of Paris treated with the marsh-mallow root hardens well in about an hour—in itself a great practical value, which those who have only worked with the plaster in the ordinary way will thoroughly appreciate.

(28) Aluminium, one of our modern metals, the basis of which is alumina, from the Latin word for clay—hence the name—was first produced on the large scale by Deville, the celebrated French chemist, Professor Wöhler being the original discoverer. Since its production in quantity, some thirty or thirty-five years ago, it has been used for a wide variety of purposes, having at one time been very fashionable when formed into articles of jewellery, which, if not valuable for their other qualities, possessed the desirable quality of extreme lightness. The low specific gravity of the metal forms, indeed, its chief characteristic, and affords constantly a method of distinguishing it from all other metals, when in the form of one or other of its alloys it assumes an appearance differing from its natural, and—to many—not very pleasant one, the colour being a tone between that

of zinc and iron. Taking the standard of specific gravity—namely, water—as 1, the specific gravity of aluminium is 2·5 or 2½ times heavier only; copper is three times heavier, silver four times, and gold eight times heavier.

(29) At the conclusion of our last note on the subject of "Fuel Combustion" (No. 24) we stated that, so far as the rapid and complete combustion of a fuel was concerned, the condition in which it was was everything; it is, at all events, of practical importance when using fuels,—of such importance that further remarks upon the subject will be of value to our young readers. A highly combustible material may, indeed, be so placed that it will be a difficult matter to get it lighted and burned away. This may be tested simply enough, but yet in such a way as to convey some lessons of practical value in the matter of combustion. Take a newspaper, and crumpling it up so that it will in a measure stand upright on the floor, apply a lighted taper to the lower part, next the floor; in a second or two the paper will be a sheet of active flame, which will soon exhaust itself, and leave in a minute or two black patches of ash. Take another paper of the same size, lay it flat on the floor, and set fire to it at one part, as before. The chances are that the flame first created will soon die out, or, if not extinguished, it will creep slowly along the sheet, and ten chances to one it will get extinguished rather than burn completely away. Take another sheet, fold it up flat into small compass, and try to set this on fire lying flat on the floor; the task of wholly consuming or burning it completely away will be no easy one. It will be facilitated, and greatly, by placing it on edge and keeping it vertical, and setting fire to it at the foot. The difference in the results has arisen wholly from the condition of the combustible—the relation it had to the air, which was necessary first to be heated, and the oxygen of which was ready to enter into combination with the carbon and hydrogen of the combustible. And the influence of a high temperature in so preparing the combustible for rapid burning and complete combustion can be exemplified even by the simple experiments we have described. For let the youthful student set fire to a large sheet of paper, or some light pieces of wood, on a cold stone surface or on a cold iron plate, and then upon these warmed or upon a wooden floor, and he will at once, if observant, note the difference. The ultimate lesson derived from these experiments with combustibles, which the youthful inquirer will learn, will be that the more solid and dense the combustible, the heavier and the larger the pieces or lumps, the longer time will it take to "kindle" them or get them into a state of active burning, and the longer the time for effecting complete combustion. The çonverse of this will be brought about by the process of "division,"—of, so to say, cutting up or breaking up combustibles that the maximum of surface be obtained in order to facilitate the combinations which bring about the active combustion of the fuel. And the young reader will perhaps be surprised to learn that the whole tendency of advanced practice in the combustion of fuel for the obtainment of the high temperature now necessary in various improved processes of the arts, is to carry out the principle of division in heating the combustible; and this by so changing its condition that large surfaces are presented to the action of heat of the kindling, or already kindled, fuel, thus facilitating the combination of its constituents and of the air; that coal can be so treated that, on the application of a light, it will be flashed into flame with almost the rapidity with which gunpowder explodes when the lighted fusee touches it. Coal dust—some of it a fine impalpable powder, the quantities of which have long rendered it a nuisance difficult to be got rid of—was some time ago almost successfully dealt with by one of our ablest engineers; the mechanical difficulties were such that the attempt had to be given up, but the importance of the principle of division was nevertheless amply proved by what had been done. Applied in another direction, it has been so eminently successful, as we have already said, in dealing with the absolute refuse of combustibles, that fuel in the ultimate stage of division—that of a gas—is now used everywhere in the obtainment of temperatures ranging up to points altogether beyond even the most sanguine dreams of the advanced engineers of a quarter of a century ago. On what has been done —what is daily being done—with it, the reader will find some notes in the latter part of the paper in the text entitled "The Steel Maker."

(30) To the collection of notes upon "Cements," we add another, said to be useful, for the joining of iron or steel, and gutta-percha, leather, and canvas together; and which possesses a characteristic which will be appreciated by the mechanic with whom clean surfaces free from greasy matter are not of easy attainment, this feature being that the cement is not lessened in adhesive value, or if so but to a trifling extent, even should the surfaces to be joined be greasy. The only caution to be attended to is that the surfaces be not moist or wet; they will be all the better if thoroughly warmed. The cement is made by thoroughly melting by the heat of a water bath two pounds of ordinary glue of the best quality, adding to the melted mass two ounces of gum ammoniac, carefully amalgamating the mixture. When well mixed add two ounces of muriatic acid, carefully mixing this also with the other ingredients.

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